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Scene in the Bitter Root Mountains, where the Chicago, Milwaukee & St. Paul Railway is to supplant steam with electricity.

RAILROAD ELECTRIFICATION IN THE FAR WEST.—[See page 56.]

Malaria and the Transmission of Diseases*

Radical Improvements Needed in Public Health Methods

It is curious that though the transmission of disease is a matter of such vast import to every one of us, it has received so little investigation in the past. Even up to the middle of last century our inquiries had led us little further than what I call the subscience of the subject—that is, we distinguished, classified, and named our various bodily inflictions. Bacteria are easily saprophytic and may have many paths of transmission, and I fear that we are still very much in doubt as to the most important of these numerous routes.

Some of the largest parasites were known in antiquity, but the ancients possessed quite a wrong notion of their origin, which they attributed to spontaneous generation. In the seventeenth century, however, Redi proved that this hypothesis does not hold for certain insects; and later Pallas argued that parasites originate *ab ovo*, like other animals—that is, that their eggs escape from one host and enter another host, thus leading directly to the presence of the parasites in the latter. This history possibly still holds for certain parasites; but in 1790 Abildgaard showed by experiments that some parasites of fish live not only in those fish, but a part of their existence in certain water fowl; and this extraordinary law, which may be called after De Barry's term, slightly changed, the law of metaxeny, was proved during the middle of last century to apply to a large number of Platodes and Cestodes. Subsequently Leuckart, Melnikoff, and others extended the law to cover other species, including species of Nematodes. A most important case was that of the *Filaria medinensis*, the famous guinea worm of man, which was shown by Fedschenko in 1869, following a suggestion of Leuckart, to be in common with man and a water-flea (*Cyclops*). All this constituted a discovery which was both remarkable in that it exhibited the wonderful devices of nature for propagating parasites from host to host, and was also of the higest importance to mankind (though few recognized this point at the time) because it showed us how many of our great diseases are likely to be acquired.

Let me dwell on this point for a moment. Parasites, accustomed as they are to dwell in the safe retreats of certain portions of their host's body, must be exposed to great dangers whenever they come to pass, as they must do, from one individual host to another. Thus, if this passage is effected merely by the egg, it is obvious that the eggs must be poured out in immense numbers to compensate for their immense destruction outside the body of the host, while it would always be probable that only a very minute proportion of the eggs would ever find their way again into fresh hosts of the proper species. In order to avoid these difficulties, nature, I presume through an infinite period of evolution, has enabled many parasites to acquire a more safe and certain route of entry—through other animals which are associated frequently with their first species of host. Remember that nature is as solicitous for parasites as for the higher animals which contain them. She thinks no more of man than of the minute germ which infests him.

Following upon the discovery of Fedschenko, Manson in 1877 showed that the embryos of another *Filaria* of man (*Filaria bancrofti*) develop in a species of mosquito, probably a *Culex*. The life-cycle of this parasite, up to the point to which he carried it, was closely similar to that demonstrated by Fedschenko for *Filaria medinensis;* and Manson did not complete the story. Lastly, in 1880, Laveran made the most important discovery that malaria is associated with a minute protozoal parasite of the blood; and his observations were followed by those of Danilewski and others who showed that similar parasites are to be found in many animals.

But up to the last decade of last century we still could form scarcely any definite idea as to how the protozoal parasites pass from one individual host to another. The law of metaxeny which had been proved to apply to many of the larger parasites had not been extended to the smaller ones. In 1889, however, Smith and Kilborne discovered a small parasite called *Piroplasma*, in the blood of cattle suffering from Texas fever; and more than that showed that in some mysterious way the infection is carried from ox to ox by means of certain cattle-ticks—though they did not demonstrate in any way that these parasites undergo a metaxenous stage of development in the ticks, and indeed failed to find them at all in these arthropods. In 1896 also Bruce made his famous discovery that the Trypanosomes of nagana are conveyed by certain tsetse flies, but supposed that the carriage is a mechanical one. And there the matter rested until the solution of the great malaria problem opened up to those interested a new field.

We now turn to the subject of malaria. Economically, as well as medically, it is certainly the most important disease in the tropics, perhaps in the world. It is found almost everywhere in hot climates, and even in most temperate climates during the summer. From statistics we find that as a broad general rule in malarious countries about one third of the total population suffer from attacks every year. But these figures are merely based upon records and do not cover the enormous additional number of patients who remain untreated.

It is remarkable that even more than 500 years before Christ the ancients certainly were acquainted with one great law—namely, that malaria is connected with stagnant water, such as marshes; and there are good grounds for believing that Empedocles of Sicily actually delivered Selinus from malaria by draining its marshes or by turning two rivers into them. This knowledge seems to have been generally held since ancient times, though it must have been acquired quite empirically; but Varro and Columella, at about the time of the Christian era, actually suggested that the disease is in some way connected with insects which breed in marshes. In more modern times, however, malaria has been ascribed to noxious vapors given off by stagnant collections of water—the hypothesis evidently being that the poison is some kind of chemical one. Even ten years after Laveran's discovery we were still completely ignorant as to how the malaria parasites enter the body.

At the same time, however, the hypothesis originally but vaguely mooted by Varro and Columella had been gaining ground. Indeed, Lancisi had repeated the same speculation in 1717 and seems actually to have suspected mosquitoes and to have studied them. In 1883 Dr. A. F. A. King wrote a most able paper on the subject, in which he gives no less than 19 reasons why mosquitoes are likely to carry malaria. He thought that the insects bring the poison from the marsh and inoculate it into men. Next year Laveran himself and Robert Koch independently enunciated the same speculation, but gave few reasons and no experiments in support of it. Ten years later, however, Manson repeated the hypothesis, but in a different form. By this time (1894) the parasites of malaria had been very carefully studied, and were shown to possess, not only certain forms which are provided for their propagation in the human host, but also other forms which, when the blood is freshly drawn, emit several so-called flagella. These latter forms had really led Laveran to his discovery, but their zoological significance still remained quite unexplained. Manson now urged that the flagella given off from these forms are really flagellated spores; that when mosquitoes ingest blood containing these forms the flagellated spores escape in the insect and enter its tissues, where they ripen into some further unknown stage. Then, he thought, the insect dies two or three days later on the surface of the water, and this later stage of the parasites enters the water, and finally rises in the marsh-mist to infect men. Obviously, therefore, Manson's hypothesis was quite different from King's: the former thought that mosquitoes derived the parasite from men and transferred it to the marsh, while King thought just the opposite. Neither really reached the truth: both were half right, but half wrong.

I was first drawn to the malaria problem in the year 1889, when I observed during active service in Burma that the prevalence of malaria did not at all accord with the theory of the telluric and marsh miasma. If the poison is given off in an aerial form, either from water or from soil, the disease ought to be almost uniformly distributed. Such, however, is not the case, and it really occurs principally in very small spots or pockets, generally in close proximity to stagnant water. Thus in one station where I subsequently served my regiment was severely inflicted, while other regiments, scarcely a mile distant, remained almost entirely free.

In 1907 I observed another variety, which I called dappled winged mosquitoes, and which everyone now knows were Anophelines. I first saw these in an intensely malarious quarter near Ootacamund, where I myself acquired malaria during my investigations. A few months later I obtained eight of these insects in Secunderabad, and employed them for my usual experiments. Six of them died or gave bad dissections. On August 20th, 1897, I was so fortunate as to find in the tissues of one of these insects, four days after it had been fed upon a case of malaria, certain bodies which I had never observed in mosquitoes before. These contained the characteristic pigment of the malaria parasite. Next day, the 21st, I found the same bodies in the last mosquito of my batch of eight—only they were now larger and more definite. A little later I found the same bodies in two more mosquitoes and knew that I was on the right track: I felt that the two unknown quantities of this complex equation had been simultaneously found—the species of mosquito which carries malaria, and the position which the parasites take in its tissues, namely, the wall of the intestine.

Unfortunately, my work was now interrupted for nearly six months, just at a point when I expected to unravel the whole history of the malaria parasites in a few weeks; and it was not until March of next year that I was able to take up the thread again in Calcutta. In a very short time I was able to demonstrate the presence in mosquitoes of pigmented bodies derived from the allied parasites. These bodies were found to grow regularly during one week after the insects had been fed; to reach maturity, and to produce a number of elongated spores. Now came an intensely exciting moment. What happens to these spores? According to Manson's hypothesis, they ought to liberate themselves in the water in which the insects died; but I had now shown that the insects did not die after two or three days as he supposed, but may live for weeks. I attempted to follow the spores in all directions through the insects' tissues, into the lower intestine, and even into the egg. On July 4th, 1898, however, I observed the fact that the spores enter the insects' salivary or poison glands. The full truth was now immediately disclosed, and proved to be far more wonderful than any of us had ever dreamed of. The parasites are not only taken from man by the mosquitoes as Manson had supposed and are not only put into man by the mosquitoes as King had supposed; but both hypotheses are true, and the insect carries the parasites directly from man to man. Here then was merely another case of the great law of metaxeny—which, however, was now proved for the first time to hold good for protozoal parasites. The malaria parasites, like many large ones, require two hosts for their life-cycle.

In July and August I infected 22 out of 28 healthy birds by the means of the bites of infected *Culex*—thus completing the whole story in detail. True, that was done with birds' malaria, and I had only seen the first steps of the process with regard to human malaria; but any zoologist will know that with such closely allied species the life-cycle of one is sure to be almost exactly similar to the life-cycle of the other. My work was now interrupted again, and for nearly a whole year; and it was not until August, 1899, that I was able to show directly that the human parasites have exactly the same development. Meantime, however, Koch and Daniels had confirmed my work on birds' malaria; and certain Italian workers repeated it with regard to the human parasites, even to causing infection in healthy human beings (November, 1898), three months after my similar work with birds.

A very important discovery had been meantime made quite independently by MacCallum and Opie in America (1897) who showed that the bodies which Manson had thought were flagellated spores were really sperms. Thus the large pigmented cells which I had found in mosquitoes at the same date were really fertilized macrogametes. This gave a much more correct zoological interpretation to my phenomena; but did not otherwise disturb the history which I had ascertained.

The discovery of the full life-cycle of the parasites enables us, not only to "precise" the route of infection, but to determine exactly which species of mosquitoes are concerned. Since then the work of many observers has shown that out of about 500 Culicidæ only about 25 species carry malaria, and that all of these belong to the Anophelines. So that for the prevention of malaria we are not obliged to deal with mosquitoes in general, but only with particular species.

Another discovery, concerned with one of the most important of human diseases—namely, yellow fever, was made by Reed, Carroll, Lazear, and Agramonte during the last days of last century. Without knowing the causative agent of that disease, they yet showed by direct experiments on human beings that the infection is carried directly from man to man by another species of mosquito *Stegomyia fasciata* or *calopus*. It had long been stated by epidemiologists that malaria is connected with damp and decaying vegetation, and the latter with insanitary conditions round houses. The former hypothesis was verified by the observation that Anophelines breed in terrestrial waters, and the latter was now explained by the fact that Stegomyia breed in artificial collections of water round houses. A little

* Abstract from the Huxley lecture, delivered by Sir Ronald Ross, at Charing Cross Hospital.

later Graham gave strong evidence in favor of the theory that dengue fever is carried by a species of *Culex*. Thus mosquitoes have now been incriminated as the carrying agents of no less than four important diseases of man. But this is by no means all. I have mentioned that Bruce incriminated *Glossina morsitans* as the carrying agent of nagana; and he and others now showed that the deadly sleeping sickness of Africa is carried by other tsetse flies. Various Spirochætes, especially that of tick fever, have been shown to be conveyed by ticks. A peculiar type of comparatively mild fever, of which the cause, like that of yellow fever, is still unknown, has been proved to be conveyed by sand flies. Several diseases of animals have been proved to possess a similar history; and others, both of animals and men, are suspected to lie in the same category. Perhaps, however, the most important and dramatic result was that obtained in the case of plague—the most terrible of epidemic diseases, the wonder and the despair of humanity since the beginnings of history, the scourge which was so often attributed to the direct action of God. It is caused really by the rat-flea. And this discovery signals another advance, because plague is, as we all know, due not to an animal, but to a vegetable parasite; and we therefore see that bacteria also may adopt precise routes of entry. A similar case is that of Mediterranean fever, which is carried principally by the milk of infected goats; and leprosy (another supposed scourge of Heaven) has been attributed to the bites of bed-bugs; while some are even beginning to think that measles is due to fleas.

We now have a great sanitary ideal put before us—so to manage our habitations, villages, towns, and cities that the vermin in them shall be reduced to the lowest possible figure. Scores of entomologists and medical men are now dealing exactly with the habits of these creatures and showing us how to effect the required object. It demands only intelligence, energy, and organization on the part of administrators. Unfortunately these qualities are not always forthcoming, and administration often lags years behind the dictates of science. Although 15 years have elapsed since many of the facts which I have described were discovered, I think that I may say after constant study of the subject, and with all due consideration, that mankind has hitherto not effected more than about one-tenth of the improvement of health which it might have effected already if it had put its heart into the business.

Applied Electrical Science in 1914*

Wide Field Open to Research as an Aid to Practical Application

By Prof. A. E. Kennelly †

The year 1914 will undoubtedly be signalized in the history of our world by two great epoch-making events, namely, the opening of the Panama Canal and the opening of the world-wide war. Both events may be classified as relating to engineering or applied science, the one being an engineering event of international constructiveness and the other an engineering event of international destructiveness. Both have distinct relations to electrical engineering, and both are doubtless destined to leave their impress upon human affairs for many generations. Nevertheless, we may well hope that, in the long run, the constructive effects of the canal upon international activities will outweigh the destructive effects of the war.

INFLUENCE OF THE PANAMA CANAL.

The influences of the Panama Canal are manifestly destined to be more potent on civilization than those of the Suez Canal because, to use an electrical analogy, the route short-circuited is greater. The Cape of Good Hope lies approximately in south latitude 35 degrees, whereas the Magellan Straits lie in south latitude 53 degrees. By means of the new short-circuit the whole world is virtually made smaller and the nations of the Pacific are brought into greater relative prominence. Electrical machinery and long-distance electrical control, with their concomitant modes of thought, not only actuate the locks of Gatun, but will carry their stimulating influences to all parts of the Pacific. The center of gravity of the world's engineering activities must necessarily undergo some displacement.

THE WAR'S EFFECT ON ELECTRICAL ENGINEERING.

The war has already exercised notable effects upon electrical science. On research, pioneer investigation and all that goes to pave the way for advancing engineering knowledge it has laid a heavy hand of repression, many young men having been taken from the laboratories of Europe to trenches, fortifications and graves. The influence of this setback is likely to be felt in scientific research for many years to come.

On the other hand, the war itself has had a remarkable influence upon particular branches of electrical engineering, and notably on radiotelegraph engineering. This has been stimulated by the needs of maintaining communication between co-operating forces separated by considerable distance, especially as submarine cables have been intentionally cut in a number of places. Hostile cruisers have commandeered and erected radio stations, while they have also been captured by means of notices sent out through other radio stations. For the first time in the world's history we have witnessed the regular use of radio transmission across the Atlantic, by one of the belligerent powers, for the dissemination of daily war bulletins. Radio communication has also been employed in the field along the astonishingly long lines running over hundreds of kilometers, while aeroplanes have also been equipped radiotelegraphically. Battle fleets have kept their ships in touch with radio signals, and "jamming" between hostile signalers is now recognized as a regular weapon in the new ethereal warfare. The whole war has depended upon engineering as never before.

This is a gasoline war, in which transportation to the armies in the field beyond rail-head has depended vitally on automobiles, advances of troops on the ranges of the most improved type of rapid-fire cannon, and naval contests on the results of shooting at distances not less than 6 kilometers. It is manifest that next to discipline and *morale* engineering is most important in war.

Another instance of the stimulus which war may give to engineering is afforded by the decision which has been recently announced in the press that, in view of the satisfactory experience last year with the electromagnetic drive on the United States naval collier "Jupiter," the United States Navy Department intends to try electromagnetic variable-speed drive between steam turbines and propellers on a new battleship. On such a ship the demand for high fuel economy over a wide range of speeds is particularly great. Nevertheless, if the electromagnetic drive proves very satisfactory on warships, it may be possible to extend its application to commercial vessels.

IMMENSE FIELD FOR ELECTROMAGNETIC RESEARCH OPENING UP.

Turning to more tranquil themes, the year just passed has witnessed a remarkable development in the electronic theory of the atom. It is only about two years since Dr. Laue discovered the remarkable effects of the interference of Roentgen rays passing through thin crystal plates. This discovery appears to have set ajar the door of a new world, which many pioneers such as Moseley and Bragg are rapidly opening.

The world of our immediate recognition may perhaps be described as commencing with the linear magnitudes revealed by the ordinary microscope and ending with the linear dimensions of the earth's diameter, a range in round numbers from a micron or meter-sixth up to some 10,000 kilometers, or a meter-seven, a total range of ten million millions. Beyond this we recognize a telescopically revealed world of upper magnitudes commencing, say, at a meter-seven and going up to what limit we know not, but employing measures of decades of light-years, and light is supposed to travel in one of our years through nearly ten millions of millions of kilometers, or a meter-thirteen; so that the upper magnitude world may be estimated in round numbers as from a meter-seven to a meter-fifteen, or through an explored range of about one hundred million. There is now opened to our comprehension a third and lower-magnitude world, commencing, say, at a micron, where the ordinary microscope stops, owing to the relative coarseness of light waves, and descending to we know not what lower limit, but already it is said to an infinitesimal part of a micron; that is, to the X-ray wavelength. The world of our immediate cognizance thus comes between an upper-magnitude telescopic world, with no known upper limit, and the new lower-magnitude X-ray microscope world or underworld, with no known lower limit. The underworld is also an electrical world in the sense that its dynamics and modes of exploration are essentially electromagnetic. Already the explorers in the underworld are explaining to us, from the results of their measurements, some of the mysteries of crystalline structure and holding out possibilities as to the yet deeper mysteries of atomic structure. An immense field for electromagnetic research seems to be opening on the borderland between ours and the underworld as the result of discoveries in 1914.

While notable progress has been made in the investigation of extremely short electric waves, progress has also been made during 1914 at the other end of the spectrum, or in the extremely long electric waves of long-distance radiotelegraphy. Ranges, powers and wave-lengths have all been advancing. Moreover, marked advances have been made in the construction of very high-frequency machines for radio communication. It would seem as though the progress of engineering in long-distance radiotelegraphy called for the design of exciters of sustained oscillations in the sending antenna, as distinguished from exciters of oscillations in separate groups.

Steady progress has been witnessed during the year in the direction of the manipulation, control and knowledge of high-tension phenomena in relation to transmission lines, including corona losses and over-voltages. Energy-transmission lines have increased in voltage, number and length.

APPLIED SCIENCE OF ILLUMINATION.

In the applied science of illumination, there has been a tendency to increase the use of the lumen or unit of luminous flux and to diminish the use of the candle or unit of luminous intensity. The tendency has been fostered by the difficulty which presents itself in the photometric measurements of certain new types of lamp, in which the zonal distribution of light is more than ordinarily complex. In so far as the tendency is parallel to similar movements in the past development of electrics and magnetics, it is presumably to be regarded as an advance.

In the direction of standardization of electrical machinery the publication by the American Institute of Electrical Engineers of a new edition of its Standardization Rules constitutes a distinct step in advance. The new edition is not only a great improvement upon the old, but it also covers much more ground, owing to the collaboration of many specialists in the various branches of electrical engineering. The new rules have not only presented a fine series of technical definitions, but they also abolish the antiquated preceding notion of an overload capability to be expected in electrical machinery, like a bonus on a stock transaction. The new order of ideas in regard to thermal rating allows of no overloads in regard to temperature, but it establishes clearly the principle that each and every type of electrical machine inherently possesses a certain hot-test-spot temperature that should not be expected if the particular insulating material entering into the machine is to be preserved from injury. Consistently with maintaining this limit of temperature, the capability of the machine to carry load depends upon the temperature of the machine and the cooling powers of its environments, so that in winter weather, with low surrounding temperatures, a machine may be capable of carrying considerably more load than in a hot engine room or at a summer temperature. Under specified conditions of ambient temperature the rated load may be obtained.

*Reproduced from *Electrical World*.

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Stereoscopic Photographs

Stereoscopic photography possesses numerous advantages over ordinary photography. Many subjects which in the ordinary photograph are in no way interesting, and appear insignificant, have a fresh and surprising charm when standing out in the relief of a stereoscopic photograph. A note in the German journal, *Prometheus*, in quoting the *Photographische Rundschau* on this subject, says that the large, bare foreground often necessary in photographs of buildings, monuments, and the like, enhances the subject of the photograph to a striking degree when that subject is presented in the relief of the double form. The romantic wildness of mountain regions, curious formations of rocks, and foaming water-courses make a far stronger impression stereoscopically than in ordinary pictures. The same is true of the many and changing aspects of the sea, as the sea in repose, waves, breakers, effects of sunlight and moonlight on the sea, mirages, and reflections caused by light on the water, small boats, ships, etc.

There are excellent kinds of stereoscopic outfits, so that the amateur can obtain these advantages without a very heavy tax on his purse.

New Light on the Great Toothed Divers of America

Remarkable Bird Forms of Prehistoric Times

By R. W. Shufeldt, M. D.*

For many years past the world has known of Prof. O. C. Marsh's discovery of the toothed birds. Their fossil remains showed them to belong principally to two widely separated groups of bird-forms, either one of them possessing the extraordinary, though not altogether unlooked for, character of true teeth. This discovery was made in 1870, the fossils having been obtained near the Smoky Hill River in western Kansas, the region where we find that geological horizon of the Middle Cretaceous known as the "Peteranodon Beds."

As the Cretaceous formation is earlier than the basal Eocene, and the latter having an age of some three millions of years, we may gain some idea of the vast lapse of time since these toothed birds flourished. When they came to be studied and classified, they fell into two main genera, the one being represented by *Hesperornis* and the other by *Ichthyornis*. Prof. Marsh's great work about them is now known far and wide throughout the world, and figures of the restored skeletons of *Hesperornis regalis* and *Ichthyornis victor* have been published, with text matter about them, in nearly every quarter of the globe, in several scores of tongues. They have appeared not only in all sorts of scientific books, but in every-day magazines, as well as in school and college text books.

Prof. Marsh made some very unfortunate errors in the sumptuous volume just referred to, for he announced that "the Struthious characters, seen in *Hesperornis*, should probably be regarded as evidence of real affinity, and in this case *Hesperornis* would be essentially a carnivorous, swimming ostrich."

This and other statements made by Prof. Marsh, in his description of the form in question, have since been proved to have been grievously incorrect: for it has been shown, beyond all manner of doubt, by Prof. D'Arcy Wentworth Thompson, of University College (Dundee), and by myself, that not only was *Hesperornis* an immense cretaceous diver or loon, but that *Ichthyornis* should never have been compared with a tern (*Sterna*) in order to throw light upon its affinities, for its skeleton shows that it is more nearly related to our black skimmer (*Rhynchops*), as I have pointed out elsewhere long ago. Finally, while Marsh's *restoration* of *Ichthyornis victor* and its near allies is probably quite correct, it is more than can be truthfully said of his restored skeleton of *Hesperornis regalis*, for no bird of its skeletal organization could possibly have stood in any such attitude as he has it. It is ridiculous in the extreme, and it is about time that it be superseded in our text books by a figure presenting the bird, or rather its skeleton, in a natural pose.

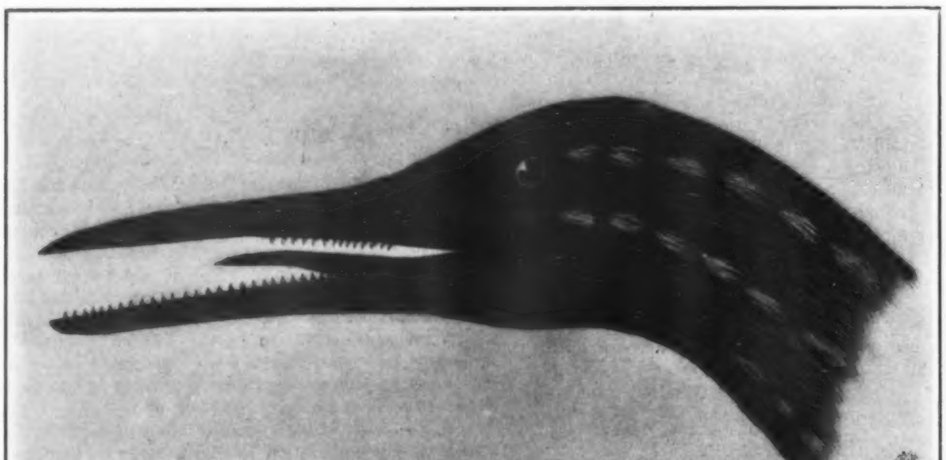

Fig. 3.—Left lateral view of the head of an adult Hesperornis regalis, as it may possibly have appeared in life. Restoration by the author, with proportions taken from a type skull by Marsh.

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Fig. 1.—The locality on Dog Creek in Montana where the fossil vertebra of an extinct, toothed diver was discovered. Photo by Charles W. Gilmore.

In the United States National Museum there is a mounted restoration of the skeleton and its restored parts, which shows very correctly the swimming posture, in so far as the skeleton goes, of this great extinct diver. Mr. Charles W. Gilmore is largely responsible for this excellent piece of work, and it will go a long ways toward correcting the gross errors of Marsh in the public mind. No doubt, were Prof. Marsh living to-day, he would be the first to admit his misconception of the form, habits, and relationships of these remarkable birds, and especially those of *Hesperornis*. Moreover, he was not the only one, during the latter part of the last century, who entertained incorrect notions in regard to these toothed, aquatic forms, now extinct for nearly four millions of years, for the author of the present article slipped up in several particulars along the same lines.

As long ago as 1886 I published in the *Century Magazine* of New York city an article entitled "Feathered Forms of Other Days," in which numerous figures, reproductions of my own drawings, appeared. Among these was a restoration of *Hesperornis regalis*, which represents the bird perched upon a partially submerged limb in the water. The attitude was suggested by Audubon's figure of the Florida Cormorant, as I have elsewhere said, and this was commented upon, years ago, in my correspondence with the late Prof. Alfred Newton, F.R.S., of Cambridge, England. No *loon* would be likely to climb up on a limb of a sunken tree in any such manner; indeed, as the legs of *Hesperornis* were oar-like paddles that protruded *laterally* from the *sides* of its body, it would have been quite impossible for it to have performed any such feat. As to the tail and feet *per se*, they probably are much nearer the truth. That *Hesperornis* had a big tail, composed of true feathers, there can be no doubt in the world; while its webbed feet, each possibly having the *contour* of the cormorant's foot, was nevertheless, structurally, more likely of the kind we find in any of the great modern divers, such as our great northern diver or loon (*Gavia immer*).

My interest in this subject has been recently revived through what has been brought to my notice from two different sources. The first of these occurred through the kindness of Mr. Charles W. Gilmore, who has charge of the fossil reptile and bird department in the Division of Palæontology in the U. S. National Museum. During the latter part of September Mr. Gilmore and Dr. T. W. Stanton, of the Division of Geology of the U. S. National Museum, were together exploring the region known as Dog Creek in Fergus County, Montana. They were in search of fossils, and were the first scientific explorers to visit that region since Prof. Marsh was there a great many years ago. It was nearly in the exact locality where that geologist discovered the fossil remains of a big bird, which he subsequently named *Coniornis altus*, publishing the fact that he believed it to be allied to the aforesaid *Hesperornis regalis*; in other words, that it was a toothed diver, related to the extinct cretaceous loons of western Kansas.

The country where this specimen was found is rugged, mountainous and extremely desolate, as will be seen by referring to Fig. 1 of the present article, which is a reproduction of a photograph made by Mr. Gilmore and kindly presented to me for the purpose for which it is now being put. A few months ago I had the opportunity to carefully study the type of Marsh's *Coniornis altus*; the result of my examination will appear later on in another connection, it being somewhat too technical to be touched upon here. This much may be said, however: the bones found by Prof. Marsh belonged to a big, toothed diver, and that in itself is extremely interesting, not to say important; for it was generally believed that those extraordinary birds were restricted to a much more limited area—that is, to the Cretaceous Beds of western Kansas.

Now the exploration of Dr. Stanton and Mr. Gilmore in this region was by no means barren of results, for the first-named scientist was so fortunate as to discover on Dog Creek, one mile above its mouth, on the left hand side of the valley (Fig. 1), the fossil remains of still another large bird, and this valuable material has likewise been submitted to me for description. I find it to belong to a large, extinct, toothed diver, and is extremely interesting when taken in connection with our studies of *Hesperornis*.

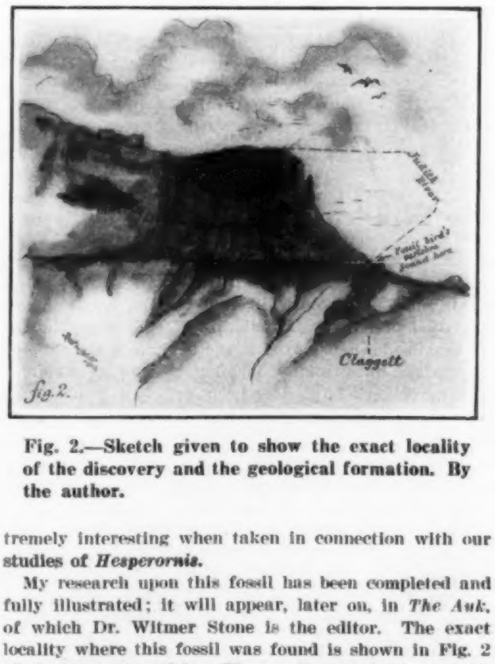


Fig. 2.—Sketch given to show the exact locality of the discovery and the geological formation. By the author.

My research upon this fossil has been completed and fully illustrated; it will appear, later on, in *The Auk*, of which Dr. Witmer Stone is the editor. The exact locality where this fossil was found is shown in Fig. 2 of the present article. The exact spot is there indicated, which is seen to be the bed assigned to the Claggett formation; it is a marine one, and at this point is overlain by the fresh water deposit of the Judith River.

These discoveries go to show that these great ancient

loons with teeth had, in cretaceous time, a very wide range over the country now known to us as western North America, and that there were probably numerous species of them, as I have pointed out in papers which, at the present time, have been accepted for publication.

Hardly had I finished with the discovered material just referred to when I received from my distinguished friend, Mr. Gerhard Heilmann of Copenhagen, the third part of his excellent work now being published on "Our Present Knowledge of the Origin of Birds" in the official Organ of the Danish Ornithological Society. This very thoughtful and painstaking piece of work contains much that is both new and interesting in regard to *Hesperornis*, for Mr. Heilmann is one who is not satisfied unless he goes to the very bottom of things. In my opinion this naturalist's conception of what kind of a bird, including its structure, this giant, cretaceous loon was like now stands among the best of those which have appeared up to date.

As did D'Arcy Thompson and I, or even more thoroughly, Mr. Heilmann has compared the material as given us by Marsh in his *Odontornithes*, representing hesperornis with the corresponding skeletal structures of loons, cormorants and other birds. This exhaustive study convinced Mr. Heilmann that the nearest living allies of the cretaceous loons are the large divers of the present avifauna, as *Gavia* and its near allies in the same family and genus. He is of the opinion that the feet of *Hesperornis* were completely webbed as in the cormorants, which view I do not recall having seen advanced by any American palæornithologist. That the true feather elements are found in the chicks of ostriches and their near allies, the emus, cassowaries, etc., and missing in the adult forms, is excellent evidence pointing to the fact that these now flightless birds are descended from forms which possessed the power of flight as well developed as in any of the best fliers of the present day. As they, in time, lost the power, the plumage *degenerated*, and the wings with the flight feathers atrophied. There can be no question but that all existing birds, whether strong fliers or those in which that power is more or less abrogated, are descended from ancestors which possessed it to the highest degree; for if this were not the case they were never birds at all, but animals of some kind, as those of some reptilian order. A beautiful living example of a bird that is now losing its flight is Harris's Cormorant (*Nannopterum harrisi*) of the Galapagos Island. This bird is a true cormorant which, with its atrophied, degenerated wings, is thoroughly incapable of flight. Its wings have gradually become shrunken from non-use; and, although perfect as wings, they have become useless to the bird for the reason that they are nowhere near large enough for the use of a bird as big and heavy as this cormorant. Its wings were not needed because the bird, being a *fisher*, on lonely islands where it had no enemies, very rarely took to flight, and as a consequence the unused limbs gradually shrunk in size until the bird could not fly, even had it the desire to do so. Recently I prepared an account of the skeleton of this cormorant and it will soon be published by the Zoological Society of New South Wales, Australia. In the plates accompanying it the atrophied wing-bones are well contrasted with the rest of the skeleton and exhibit their diminutive size and feeble development.

When we come to discuss the color of the plumage of *Hesperornis regalis* we not only pass into the realm of pure conjecture, but we are, at the same time, confronted with a question about which very little has been written. All of our now-existing American divers (*Pygopodes*) have white bellies, so it is fair to presume that the entire under parts of *Hesperornis regalis* were white. Mr. Heilmann says "whitish-yellow." Judging from the Great Northern diver (*Gavia immer*) and its near relatives, the Pacific loon, the yellow-billed loon and other species, it is almost safe to say that the upper parts were of a bluish or greenish *black*. It is likely, too, that the upper parts and neck were longitudinally striped, with stripes composed of squarish or roundish white spots—small on the neck, but increasing in size as they passed to the back and on, diminishing gradually again posteriorly.

The grounds we have for making a surmise of this kind lie in the fact that the young of many birds and mammals present a plumage, or, in the case of the latter, a pelage, which is marked with longitudinal rows of spots, and these are lost when the bird or mammal assumes its adult coloration. This is well exemplified in the young of the loons, the emus, the cassowaries, and, among mammals, the tapirs, the deer, the wart hogs, etc. In some deer the longitudinal spotting remains throughout life, as in the axis deer (*Cervus axis*).

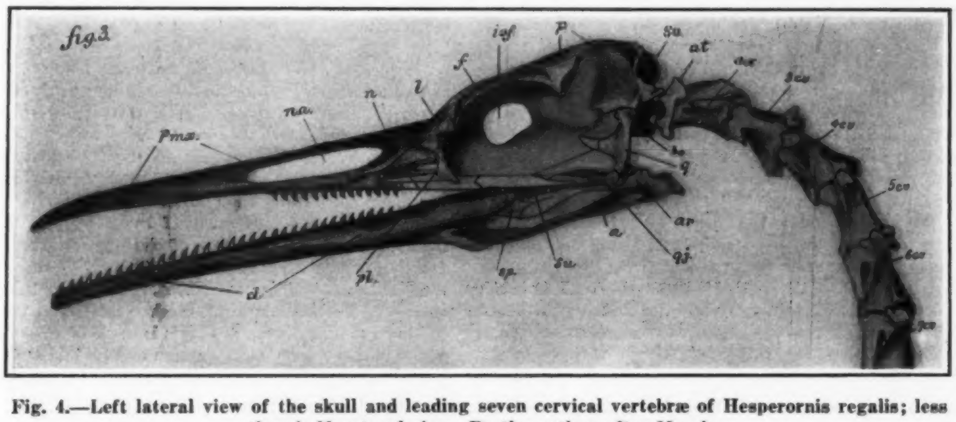


Fig. 4.—Left lateral view of the skull and leading seven cervical vertebræ of Hesperornis regalis; less than half natural size. By the author after Marsh.

Pmx, premaxillary; *n.a.*, nasal aperture; *n*, nasal; *l*, lacrymal; *f*, frontal; *i.o.f.*, interorbital foramen; *p*, parietal; *so*, supraoccipital; *d*, dentary; *pl*, palatine; *sp*, splenial; *su*, surangular; *a*, angular; *qj*, quadrato-jugal; *cr*, articular; *q*, quadrate; *bo*, basioccipital; *at*, atlas or first cervical vertebra; *ax*, axis or second cervical vertebra; *3 cv-7 cv*, the third to the seventh cervical vertebræ, inclusive.

Now, it is a well-established law in phylogeny that very frequently the *young* of *existing* mammals and birds assume a pelage or a plumage which closely resembles the coloration of the *adults* of their very remote ancestors. This being the case, and especially as the young existing loons are spotted, it is quite or even more than likely that the ancestor, *Hesperornis*, of our present-day loons had rows of longitudinal spots adown its upper parts, and, as I say, on a ground color of a black or a bluish or greenish black.

Mr. Heilmann ably advances this theory in his work; I fail to see any reason for its not having been the case, and a good deal of likelihood that it was. In Fig. 5 of the present article I present a photographic reproduction I made from a plate in his Part III, which was made from his original painting of a group of cretaceous loons (*Hesperornis*), as they may have appeared during the time in which they flourished. Basing it upon conjecture along similar lines, I have also made a drawing of the head of an adult *Hesperornis regalis*, which is here reproduced in Fig. 4. This is somewhat less than the size of nature and was modeled over the skull shown in Fig. 3, which I photographically copied from Marsh's plate, reduced in the same proportion as Fig. 4 (Plate XX, *Odontornithes*), and which gives the entire skeleton half natural size. In my figures the individual bones are lettered, their names being given in the legend. This has never been done before in the case of this extinct, toothed, cretaceous loon, and I trust it will be of use to comparative avian osteologists.

Radio-Active Fertilizers

SCIENTIFIC farmers will be interested in the account given in the *Chemiker-Zeitung* of the experiments made by Prof. Dr. Julius Stocklasa to determine the influence of radio-active fertilizers upon the growth of plants. These experiments were carried on for a number of years partly under glass, partly in fields set aside for the experiments, and included the use both of natural radio-substances (such as masturan from Joachimsthal, water from the same place, and also water from Brambach and Franzensbad) and of artificial solutions (such as chloride of radium). In his earlier experiments Dr. Stocklasa obtained considerable increase in the size of the plants by using determined and not too strong treatments containing nitrate of uranyl and nitrate of lead. Similar experiments were also made by other investigators with "stimulating" or "catalytic" agents, as they were formerly called. Stocklasa then went systematically to work to investigate the radio-activity and made experiments to determine how the activity of a certain bacillus (*Azotobacter chroococum*), which assimilates elementary nitrogen and converts it into organic forms, is increased by passing radio-active air through its cultural solution. As these investigations yielded positive results he then examined the effect of the emanation upon the higher forms of plant life. It was shown by experiments which were intended to hasten the process of germination that the amount of radio-activity of the water given to the ground in which the experiments were made must vary for different plants, and that to use an unvaryingly fixed strength, in order to obtain an increase of growth, too often resulted in a checking of growth. For example, the amount of non-watery substance gained in one hundred plants was:

	With radio-active water.	With water not radio-active.
Pisum arvense	68.73 g.	21.37 g.
Vicia faba	128.87 g.	60.09 g.
Lupinus angustifolius..	37.93 g.	18.45 g.
Hordeum distichum....	90.85 g.	9.06 g.

Of course the decline in the activity, as time went on, of the respective waters was taken into account. During an experiment which lasted 23 days extra increases in non-watery substance of between 62 and 158 per cent were noted in lentils, peas, and wheat. If, though, the water used was too strongly filled with radio-activity—300 to 600 mache units per liter renewed every fourth day—the result was reversed. It can go so far that the leaves become a reddish brown, that is, the chlorophyll is decomposed.

Our investigator found, in particular, in the production of seed that by watering with a radio-water of about 50 to 100 mache units per liter the yield can be increased from 64 to 117 per cent.

Stocklasa also investigated with the aid of glass covers ("emanatoria") the effect of radio-active air upon the development of plants. Using exactly the same soil he surrounded the plants with cylindrical glass-bells into which no emanation was introduced. The result showed that there was a more rapid development of the blossoms in the active air.

These experiments are, therefore, not only most interesting from a scientific point of view, but have also great practical value. Agricultural experiments with radio-active fertilizers have been made before this, but it would seem that the most of such work must still be left for a time to the experimental stations. At the present moment it only pays to use such a fertilizer where the nature of the soil is suitable in itself. Our investigator says further that the radio-active treatment must be adjusted to the nutritive substances of the soil and to the general constituents of vegetation.

An Electrically Driven Warship

As a result of the successful operation of the electric power system in use on the U. S. naval collier "Jupiter," it has been announced by the Navy Department that the same general system will be installed in the new superdreadnought "California." This will be the first electrically driven warship, and it will have a minimum speed of 21 knots.

Fig. 5.—A group of cretaceous loons (Hesperornis regalis) as they appeared three or four million years ago. Restoration by Gerhard Heilmann of Copenhagen, and reproduced from a photograph by the author.

Military Surgery

Some Lessons Taught by the Present War

By Our Berlin Correspondent

Dr. Payr, the celebrated Leipzig surgeon, recently delivered a remarkable lecture before the war correspondents of the Germany army on his personal experience in the field. He has, from the very beginning of the war, devoted to the military authorities the whole of his time and his exceptional knowledge, and in his capacity as General Surgeon to the Saxon army he has been in a position to collect the most valuable experience. In fact his lecture, of which an abstract is given in the following, may be considered as the most authoritative statement yet made public on the lessons taught by the present war in the field of military surgery.

The learned professor at first cautioned his hearers against the many drawbacks of military surgery. There was, primarily, the difficulty of watching the course of a given case, patients being often lost sight of two or three days after an operation, so that the success of the latter cannot always be ascertained. Further, there is a risk of the surgeon being hampered in his work by sheer scrupulousness, antispetic conditions being, of course, far less satisfactory than at home, in his own clinic. Another risk, finally, is the unavoidable rush of work which may induce the surgeon to proceed to operation without mature consideration of actual circumstances.

The projectiles concerned in the case of bullet-wounds are: infantry projectiles, shrapnel bullets, shell fragments, bomb fragments and aeroplane arrows. To these should be added dumdum projectiles, bullets deflected from their original course, and what might be termed indirect projectiles, viz. fragments of clothing, coins, and other objects from the soldier's pockets, which have been forced into the wound. The effect of projectiles mainly depends on their percussive force, size, shape, material, direction and goal; as well as on the number, firmness and tension of the organs struck.

The aeroplane arrow is a new weapon which has made its first appearance in the present war. It is a steel rod of the thickness of a pencil, with pointed shaft. The rear end is grooved out square, so that the point is heavier than the end. As an arrow such as this falls vertically to the ground, from a height of, say, 1,500 meters, it will reach a speed of 200 meters per second, which is equivalent to the velocity of a rifle bullet. In fact, the wounds made by these arrows are very serious.

According to an old classification the lecturer distinguishes several categories of shots: Ricochets, when the projectile does not penetrate into the body; embedded shots ("Steckschüsse"), when the projectile sticks fast in the body, and piercing shots ("Durchschüsse"), when the projectile pierces the body and comes out at the other end. The degree of harm done to the tissues and organs obviously depends on a number of accessory circumstances. It was thought in former times that blood vessels could bend out of the way of projectiles. However, modern infantry projectiles have been found to penetrate right through the vessels, even small arteries whose diameter does not exceed that of a quill being pierced. This is why a far greater number of artery lesions have to be dealt with in the present war.

Wounds made by modern projectiles in bones and joints are of especial importance. At short range bones will be shattered into a number of fragments. As the distance increases there is a growing tendency for the projectiles to pierce the bone, and just to produce one or two cracks in the neighborhood of the hole. The long tubular bones, which are hard as ivory, will be split even at very considerable distance, say 1,600-1,800 meters, whereas bones of a more spongy texture, such as the joint of the knee, are pierced smoothly. This is why shots through the joints take a relatively benign course.

The possible effects of shot-wounds are hemorrhage, pain, shock, mutilation, and death. As regards pain, it is obviously among the foremost duties of the surgeon in war to see that the wounded may as soon as possible get the benefit of alleviating remedies. The general practice now is to administer at the earliest possible moment a morphine injection.

Modern warfare is liable to result in a special abundance of wounds of the head, soldiers, on firing from the trenches, having to advance their heads. There are two distinct types of head shots, viz., on one hand embedded and piercing shots, in the case of which the bullet traverses the head directly or sticks fast in the skull or brain; and on the other tangential or "groove" shots, when the projectile, as it were, plows a groove through the skull bone. Tangential shots should be treated differently from embedded and piercing shots, bone fragments severed by the bullet producing practically always serious infection.

Most shots through the neck are benign, though there are some vital organs concerned, blood vessels, nerves, spinal marrow, and the oesophagus and windpipe. If the windpipe and larynx are affected, operation should be proceeded with as promptly as possible, thus preventing any risk of stifling.

Shots through the chest are, of all shots dealt with in modern warfare, those most easily treated. The Japanese used to say that their men, in the case of simple breast shots, could return to the firing line after a week or so. According to German experience in the present war such patients, even in case the lungs have been pierced, will, at least, be transportable after ten to fourteen days. Though they may for some days go on coughing out blood, they will in no way be inconvenienced as far as their general condition is concerned. If the heart or aorta has been struck, the surgeon's aid, of course, is of no avail, such patients being brought in too late from the battle-field. Whereas in time of peace it is quite feasible to remove a projectile from the heart, saving the patient's life by a heart suture, any attempt at such an operation, in warfare, would be futile. As it is, modern projectiles are doubtless more humane in their effects than the lead bullets of old, and provided the ribs have not been injured the wounded can, after quite a short time, be restored to full fighting ability.

Shots through the abdomen are an item much discussed in modern war surgery. In time of peace, it is an absolute rule to operate as soon as possible by means of a cut through the abdomen, thus staying the blood, and by opening part of the stomach and the intestines, to make the wound inoffensive and prevent any infection liable to result in peritonitis. Already the South African war, however, has shown such shots to be more benign in case operation is foregone. In fact, there are a number of instances in the present war, in which good results were obtained by a very simple treatment, the patient being kept for a week absolutely quiet and without food or drink. When this limit was not observed the condition of the patient would invariably become worse.

The lecturer next proceeded to answer the question as to how bullet wounds should be treated. According to the best German practice the following principle is adopted: A certain amount of infection should be, in any case, accounted for, which cannot be reduced by any measures whatsoever. If a patient has, for instance, received a shot through the arm, a certain number of microbes have penetrated into the wound, which it would be impossible to reduce. Rinsing the wound with water or rubbing it with antiseptics, so far from being of any avail, has been found to be harmful, the antiseptic liquid diminishing the vital strength of the tissues. However, no new noxious agents should be added to those microbes. Experience shows that healthy subjects will deal with a given number of bacteria, provided no further germs are allowed to enter the wound. This is the principle controlling the first phase in the treatment of the wounded. The surroundings of the wound are no longer washed and cleaned with soaps as once upon a time, but a piece of aseptic gauze is applied to the wound, such as is contained in the roll of bandage carried by every German soldier and officer in the field. The first dressing is thus applied, which the men themselves or their comrades are trained to do very cleverly.

Another method to prevent the microbes from multiplying is what is termed the arresting process. The parts round the wound are brushed over with tincture of iodine or mastisol. The microbes are fixed by mastix; another advantage of this process is that the aseptic gauze is attached to the wound, thus preventing the dressing from being shifted. These methods have given excellent results.

Provision must, of course, be made for the wounded to undergo long and difficult transports, especially in the case of injury to the bones and joints. Splints have often to be improvised. In fact, the surgeon, in time of war, must show much ingenuity in making shift with anything happening to be at hand. The wood of a young tree, sticks, etc., are, for instance, used as splints, but practical splints have also been made from braided straw.

The final treatment of wounds comprises a number of other problems, but a point should be made of avoiding too much zeal. The wound being well dressed and covered with aseptic gauze, there is no need for the whole bandage being exchanged, it being sufficient to renew the outer dressing. Wounds on which the first dressing—made from the man's own dressing materials—had been left, were found after a week to be healed. The greatest care should in any case be used in renewing the bandage, lest any microbes be allowed to penetrate into the wound. Cuts through the windpipe and the tying up of pierced blood vessels should, of course, be made on the very battle-field, whereas the decision as to whether any wounded members should be amputated must be left to the further treatment.

No importance is now attached to the removing of projectiles, if the latter cause no inconvenience. This is true of infantry projectiles. According to the lecturer's experience, the German steel sleeve projectile, for some unknown reason, is more humane than the French copper alloy projectile which frequently causes pain. Shrapnel bullets, which are round, have far less impact and percussive force than infantry projectiles. Penetrating into the deeper parts of the body, along with such foreign bodies as pieces of clothing, etc., they are apt to produce suppuration. In 70 to 75 per cent of shrapnel wounds under treatment, suppuration has been observed, a slight quantity of chocolate-colored liquid coming out of the wound as this is opened. Shell fragments likewise carry along foreign objects and thus give rise to suppuration; they must therefore be removed.

Artillery wounds, which are so frequent in the present war and which by no means take an always benign course, are a danger of their own. They give rise to suppuration of the tissues, gas phlegmons and tetanus. Good results have in many cases been obtained with the inoculation of a tetanus serum.

Personally, the lecturer was able to record a number of striking successes in his surgical practice during the first months of the war. Ordinary shots through the fleshy parts of the members nearly always take a very gratifying course. In many cases the men were restored to fighting ability after a week, though they had only been treated with the dressing material contained in the small parcels carried by each soldier. Infantry bullet shots through joints would take a very benign course if the wound was treated aseptically and, if required, dressed in splints, shortly after the injury.

The effects of aeroplane bombs are very much different from those of bursting shells, the injuries even produced by small fragments being so extremely serious as never witnessed by Dr. Payr in the case of shell fragments. Another unpleasant feature of aeroplane bomb fragments is their cutting like knives deep into the members and there piercing the vessels.

Employment of War Prisoners

Sixty thousand prisoners of war have now been assembled at the Münster camp on the Lüneburg Heath, states *Vorwärts*, where they are cultivating the waste lands. The majority of the men are French, though there is also a number of Belgians, Russians, and English in the camp. Many previous attempts had been made to cultivate this huge tract of moorland country, which is well known to travelers between Hamburg and Berlin, but the chronic scarcity of agricultural laborers in peace time had always hindered the project. The local authorities of Hanover accordingly appealed to the military administration to make use of war prisoners for this purpose, and the permission was at once given.

One example may be given (says *Vorwärts*) of the manner in which the work is proceeding. In the district of Neustadt, near Hanover, the cultivation of the so-called Rodewalder Bruch had long been contemplated. The District Council purchased a large tract of this country, which, with the help of 2,000 prisoners of war, is being broken up and made ready for cultivation. In due course it will be divided up into thirty farm estates. Barracks for the prisoners are being built, largely by the aid of the captives themselves, but later on these buildings can be used as cattle sheds and corn stores. The new colony has been christened Lichtenhorst, and if the winter is favorable it is hoped to have the work so far advanced that the first crops can be sown next spring. In this case Hanover will next year have many hundred acres of new land under cultivation with wheat, potatoes, etc.—*London Daily Telegraph.*

An Experiment in Forestry.

The Laurentide Company of Quebec, producers of pulp and pulpwood, is trying an interesting experiment in reforesting its non-agricultural cut-over lands. It is also importing reindeer from Newfoundland to see if they can take the place of dogs in winter woods work.

Installation of a Gas Engine*

Points to be Observed in Buying, Transporting, Placing and Starting

There are a number of points that should be considered before purchasing a gas engine, one of which is the amount of power required for the work to be done. It is generally advisable, no matter what style of engine is to be purchased, to buy a unit somewhat larger than may at first seem necessary. It is always well to have some power in reserve, because an engine working under an excessive load is inefficient and involves a money loss to the owner on account of the wear and tear on the engine.

The style of engine to be used is determined by the location and the nature of the work to be performed. If the engine is used in a fixed location a stationary type should be selected, whereas the portable type and the traction engine must be selected when the engine is for use at various points and when loads are to be hauled. The selection of the right type is fully as important as the selection of the right make; also, while attractive paint and a high polish are desirable, these tell very little of the real value of the engine.

When repairs are necessary, the importance of having an engine which has been standardized is fully realized by the purchaser. Repair parts should be obtainable at convenient points within a few hours, because delays in waiting for repair parts usually prove expensive.

It is important to bear in mind that the rated horse-power of an engine is not always a reliable basis for comparison with the actual power that the engine will deliver. There are many gas engines on the market rated at five horse-power, for example, that will hardly have a maximum output of as much as five horse-power under regular operating conditions. Again, there are engines built by reputable manufacturers that deliver continually an overload of as much as 20 per cent above their rating. If there is any doubt in the mind of the purchaser as to the power that it is possible to obtain from an engine, he should insist upon proofs of the actual brake horse-power.

When the engine has been purchased, the next thing to consider is where it is to be placed. In selecting the position for the engine, note that it ought to be placed in the cleanest, driest and lightest spot obtainable. If it is to be belted to machinery that is already in place, it is necessary to decide where the flywheel will be located, and the foundation should be made with this in mind. If the machinery is to be installed later, suitable position for it must be determined at the time the engine is installed in order to insure that no difficulties will be met with in transmitting the power. If the engine is installed in a large room, a small room or space should be partitioned off around it in order to keep out dust and dirt. Under all circumstances, never allow a gas engine, or any other engine for that matter, to run in the same room with emery or polishing wheels.

Assuming the engine to be of the stationary type, the purchaser should obtain a templet and anchor bolts, generally furnished with each engine. The templet is a wooden frame of the size of the bottom of the base of the engine, having holes in it to match the holes in the base of the engine frame.

THE FOUNDATION.

The dimensions of the foundation at the bottom should be at least twice the length of the engine base and not less than two and one half times the width, and the depth of the foundation should be equal to its length. The shape of the foundation is then made in the form of a frustum of a pyramid, sloping up toward the top, where it is only about three inches larger on all sides than the base of the engine. When the hole has been dug in the ground, a form for the concrete must be made and then the concrete is mixed as follows: one sack of good cement, two wheelbarrows of sand, and three wheelbarrows of crushed rock or small gravel, well mixed with water to make it easy to handle. When putting the concrete into the form it is advisable to use old scrap iron of all kinds, chains, wire, etc., to reinforce the concrete and keep it from cracking. Put in the concrete and scrap iron together, tamping it tightly into the form. Before putting in the concrete, however, place the anchor bolts in the bottom of the hole, with large heavy washers on their heads, and use the templet to locate them properly at the bottom; then run the nuts down on the anchor bolts far enough to allow the templet to rest upon them while locating the bolts at the top at about the level where the engine will be set on the foundation. Then fasten the bolts in some way so that they will not move while the concrete is being put in place. The wooden templet is left on the top of the foundation, the nuts, of course, being removed when the foundation reaches them, and the engine is set on the top of the templet, as it is advisable to use a thin strip of wood between the concrete and the cast iron of the base. The foundation should be left to set at least four days before the engine is placed on it.

REMOVING AN ENGINE FROM A RAILROAD CAR.

The foundation now being ready, we will assume that the engine has arrived in a railroad car at the station, and that it is to be removed from there by the purchaser. A few points relating to this operation will prove of value. The engine has been delivered to the transportation company by the manufacturer or dealer, properly packed for shipment. The responsibility of the manufacturer or agent stops at this point, and the transportation company is supposed to deliver it to the purchaser in perfect condition. The engine, if of a heavy type, has been transported in a separate car, and is left on a side track accessible for teams. The first thing to do is to have the local station agent make an inspection of the engine in the presence of the purchaser or his representative, to see if it is in good condition, and that no damage has been done to it in transportation. Should any damage be revealed at this inspection, the station agent should be required to make a notation of the damage upon the expense bill before the freight is paid. After this is done, the transportation company is liable for the damage, if any, and the buyer is safe in unloading and taking charge of the engine.

If any timbers or assistance are needed in unloading the engine from the car, the transportation company, through its agent, is supposed to furnish them. If the transportation company furnishes bad timbers for this purpose and an accident is caused thereby, the mere acceptance by the purchaser of the bad timbers does not place the responsibility upon him. The engine should preferably be moved onto a flat top dray wagon without springs. In moving the engine, take care to see that it is properly supported at all times, and see where each step in the moving is going to leave it. If any accident happens to the engine before it is clear of the car or before it is taken off the skids conveying it from the car to the wagon, the transportation company is liable for the damage, because, being a local shipment, the company is supposed to remove it from the car and the purchaser is merely acting for the company when taking the engine from the car. After the engine is placed on the wagon the purchaser is entirely responsible for it.

As an example of what may be encountered in unloading an engine, the following experience may be mentioned: An engine arrived at its destination in good condition, and the car was set on a siding near a pile of ties that were to be used in unloading. Some other timbers were also necessary, which the agent of the railroad company furnished, but these were not as strong as the man unloading the engine required; however, the station agent informed him that he would have to use them. He went on with the operations, taking extra precautions to brace the weak timbers, but just as the engine was about half way between the car and the wagon one of them gave way and the engine went into a ditch upside down. The man in charge of the unloading went to the long-distance telephone and called up the general agent of the manufacturing company, stating the circumstances and asking for instructions. He was told to inform the station agent that the engine could not be used, and that it would be left on the railroad company's hands. A new engine was loaded at the factory the same day and shipped, and in that case ample assistance was rendered in unloading the new engine. The first engine was loaded by the railroad company onto a car and returned to the factory free of charge; the bill for the necessary repairs was rendered to the railroad company, and was paid without a damage suit.

After the engine is safely placed on the wagon it should be conveyed by the safest and easiest road to the place of installation. Avoid uneven ground and bad street crossings; take plenty of time, and be sure of every move. Always release the team from the wagon while loading and unloading the engine. The unloading is greatly simplified if two trenches are dug for the wheels of the wagon so that the axles almost touch the ground. In this case, the timbers on which the engine is handled will be more nearly level. If they are entirely level, rollers may be used under the skids to which the engine is fastened. If, however, the timbers slope at all rollers should not be used. The main thing is to avoid haste, and not to permit anything to interfere until the engine has been placed on the foundation.

INSTALLATION OF AUXILIARIES.

The next thing is to select a suitable place for the battery box. This place should be dry and free from vibration. The wiring is now connected. If natural gas is to be used as a fuel, it is necessary to have a special mixer, which will be furnished by the manufacturer of the engine. All that is necessary is a gas bag or tank and piping to allow the charge to be drawn quickly into the cylinder. Some engines use gasoline for a start and then switch onto the natural gas, while others start directly on the gas. If the engine *will* start on the gas, there is no reason for using gasoline.

If liquid fuel is to be used it is advisable to place the fuel tank outside the building, and it is still better to bury it in the ground. After the tank has been buried in a suitable place, it is an easy matter to arrange the piping to the fuel pump on the engine. As far as possible, this piping should be underground, as it is out of the way. A pipe for the fuel, passing from the pump to the mixer, and a pipe for the overflow to return from the mixer bowl to the tank, must be provided. If the overflow pipe stops at the top of the fuel tank, it will not be necessary to have a vent hole at the top of the tank, as the air will flow into the tank from the overhead pipe, which will not always be full of gasoline. The pump pipe should pass to the bottom of the tank and should be provided with a light screen to prevent foreign substances from passing into the mixer.

STARTING A NEW ENGINE.

After the engine is properly installed, the first thing is to start it running. This is done by turning on the battery switch, setting the needle valve in the starting position, turning off the air damper, releasing the compression, and giving the flywheel a few turns, which will put it in motion. After the engine has made a few revolutions, open the air damper, close the needle valve to the running position, put the relief cam back into place, and let the engine run, watching for developments. It is, of course, presumed that all the oilers and grease cups have been filled, and that all movable parts have been oiled with the oil-can. Now see that water enters the cylinder cooling jacket within five minutes, or stop the engine, as it is not safe to allow it to run without cooling water on the jacket. It is best to allow the engine to run an hour or so without any load, and to watch the bearings to see that they do not become overheated. In case of doubt on any point, stop the engine and examine it.

In cold weather, a gasoline engine is more difficult to start than in warm weather, the reason being that gasoline, in changing from a liquid to a vapor, reduces its temperature about 30 deg. Fahr. If the air is cold on the outside of the cylinder and the mixer has taken in vapor 30 degrees colder, it is easy to understand that this would interfere with the proper vaporization. Hence, it will be difficult to start the engine. There are several methods of overcoming this difficulty, either by warming the gasoline, warming the air, or by using one part ether and four parts gasoline for a start; this will make a liquid that will vaporize readily several degrees below zero. To warm the gasoline is a process which is dangerous and should only be attempted as a last resort. It can be done safely only by using hot water or a hot cloth. The air may be warmed by heating a piece of iron red-hot and holding it at the mouth of the intake pipe, allowing the air to pass over it as it goes into the intake pipe, after which it joins the gasoline vapor and heats it.

* Reprinted from *Machinery*. From an article prepared mainly from notes by J. L. Hobbs, gas engine expert.

Motor Fuel in Germany

A very large proportion of the supplies of gasoline used by motor cars in Germany, has been obtained from the United States, as well as considerable quantities from Russia, and the East Indies. It is believed that these sources of supply have now been effectively cut off, so that, outside of accumulated stock, the wells of Gallacia are the only ones from which fuel supplies of this class can be obtained, and these wells can be depended on for little more than crude oils, and these in no great quantities. It is reported that alcohol and benzol are used exclusively by the cars in the military service; but the supply of alcohol must be limited, as the grain, potatoes, etc., from which it is made, will undoubtedly soon be required for food purposes, and it is doubtful if the supplies of benzol are anywhere near sufficient. In a machine-made war, such as the present one pre-eminently is, the question of a supply of motor fuel is a most important item, and it will be interesting to see how Germany will solve the problem.

A Great Railway Electrification Project

440 Miles of the Chicago, Milwaukee & St. Paul Mountain Lines to be Operated by Electric Power

The Chicago, Milwaukee & St. Paul Railroad has decided to electrify four engine divisions of its Puget Sound lines, extending from Harlowton, Montana, to Avery, Idaho, a total distance of about 440 miles, aggregating approximately 650 miles of track, including yards and sidings.

Work has already been started on the first engine division, consisting of 113 miles of main line track between Three Forks and Deer Lodge, Montana, and contracts have been let to the General Electric Company for the electric locomotives, substation apparatus and line material. Power will be secured from the Montana Power Company, which will also construct the transmission and trolley lines.

While the four engine divisions of 440 miles comprise the extent of track to be equipped in the near future, it is understood that plans are being made to extend the electrification from Harlowton to the coast, a distance of 850 miles, should the operating results of the initial installation prove as satisfactory as anticipated.

The plans of the Chicago, Milwaukee & St. Paul Railway are of especial interest, as this is the first attempt to install and operate electric locomotives on tracks extending over several engine divisions, under which condition it is claimed the full advantage of electrification can be secured. The various terminal and tunnel installations have been made necessary, more or less, by reason of local conditions; but the electrification of this road is undertaken purely on economic grounds with the expectation that superior operating results with electric locomotives will effect a sufficient reduction in the present cost of steam operation to return an attractive percentage on the large investment required. If the anticipated savings are realized in the electric operation of the road this initial installation will constitute one of the most important milestones in electric railway progress, and it should foreshadow large future developments in heavy steam road electrification. The success of electric operation on such a large scale will, at least, settle the engineering and economic questions that enter into the advisability of making such an installation, and will limit similar future problems to the means of raising the money expenditure required.

The first step taken toward electrification by the Chicago, Milwaukee & St. Paul Railway was to enter into a contract with the Montana Power Company for an adequate supply of power over the 440 miles of main line considered for immediate electrification. The precautions taken, both by the railway company and power company, to safeguard the continuity of power supply should guarantee a reliable source of power subject to few interruptions of a momentary nature only.

The Montana Power Company covers a great part of Montana and part of Idaho with its network of transmission lines, which are fed from a number of sources of which the principal ones are tabulated below:

Madison River	11,000 kilowatts
Canyon Ferry	7,500 kilowatts
Hauser Lake	14,000 kilowatts
Big Hole	3,000 kilowatts
Butte, steam turbine	5,000 kilowatts
Rainbow Falls	21,000 kilowatts
Small powers aggregating	7,390 kilowatts
Total power developed	68,890 kilowatts

Further developments, part of which are under construction, are as follows:

Great Falls	85,000 kilowatts
Holter	30,000 kilowatts
Thompson Falls	30,000 kilowatts
Snake River	20,000 kilowatts
Missoula River	10,000 kilowatts
Total	175,000 kilowatts
Total power capacity, developed and undeveloped	244,000 kilowatts

The several power sites are interconnected by transmission lines, supported on wooden poles and operating at 50,000 volts for the earlier installations, and on steel towers and operating at 100,000 volts for later installations. Ample water storage capacity is provided in the Hobgen reservoir of 300,000 acre-feet, supplemented by an auxiliary reservoir capacity at the several power sites, which brings the total up to 418,000 acre-feet. The Hobgen reservoir is so located at the head waters of the Madison River that water drawn from it can supply in turn the several installations on the Madison and Missouri rivers, so that the same storage capacity is used a number of times, affording an available storage capacity considerably greater than is indicated by the figures given. It would seem, therefore, in changing from coal to electricity as a source of motive power, that the railroad is amply protected in respect to the reliability and continuity of the power supply.

Due to the great facilities available and the low cost of construction under the favorable conditions existing, the railway company will purchase power at a contract rate of 0.00536 cent per kilowatt-hour, based on a 60 per cent load factor. It is expected, under these conditions, that the cost of power for locomotives will be considerably less than is now expended for coal. The contract between the railway and power companies provides that the total electrification between Harlowton and Avery, comprising four engine divisions, will be in operation January 1st, 1918.

In order to connect the substations with the several feeding-in points of the Montana power transmission lines, a tie-in transmission line is being built by the railway company that will permit feeding each substation from two directions and from two or more sources of power. This transmission line will be constructed with wooden poles, suspension type insulators, will operate at 100,000 volts, and will follow, in general, the right of way of the railway company except where advantage can be taken of a shorter route over public domain to avoid the necessarily circuitous line of the railway in the mountain districts.

The immediate electrification of 113 miles will include four substations containing step-down transformers and motor-generator sets with necessary controlling switchboard apparatus to convert 100,000-volt, 60-cycle, three-phase power to 3,000 volts direct current. This is the first direct current installation using such a high potential as 3,000 volts, and this system was adopted in preference to all others after a careful investigation extending over two years. The 2,400-volt direct current installation of the Butte, Anaconda & Pacific Railway in the immediate territory of the proposed Chicago, Milwaukee & St. Paul electrification has furnished an excellent demonstration of high-voltage, direct-current locomotive operation during the past year and a half, and the selection of 3,000 volts direct current for the Chicago, Milwaukee & St. Paul was due, in a large measure, to the entirely satisfactory performance of the Butte, Anaconda & Pacific installation.

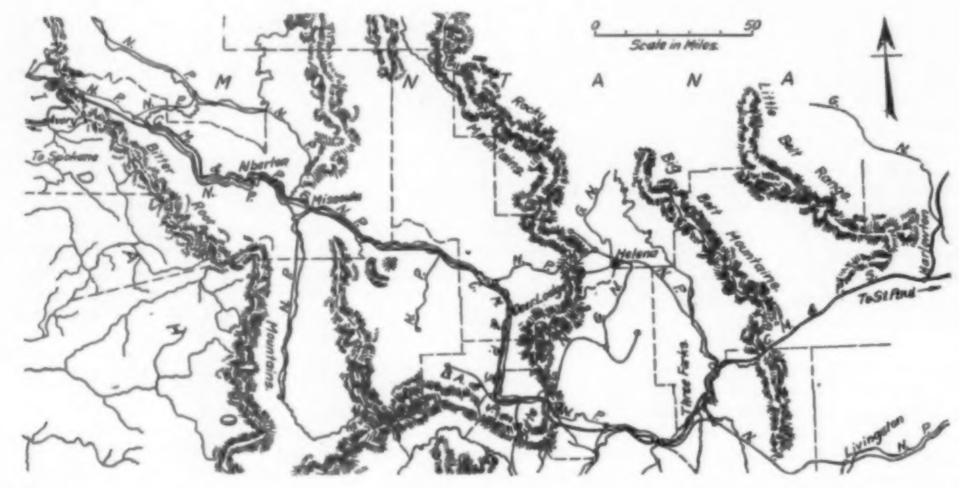
The equipment for this road was also furnished by the General Electric Company, and a comparison based on six months' steam and electric operation shows a total net saving of more than 20 per cent on the investment or total cost of the electrification. These figures, of course, do not take into account the increased capacity of the lines, improvement to the service, and the more regular working hours for the crews. The comparison also shows that the tonnage per train has been increased by 35 per cent, while the number of trains has been decreased by 25 per cent, with a saving of 27 per cent in the time required per trip.

SUBSTATIONS.

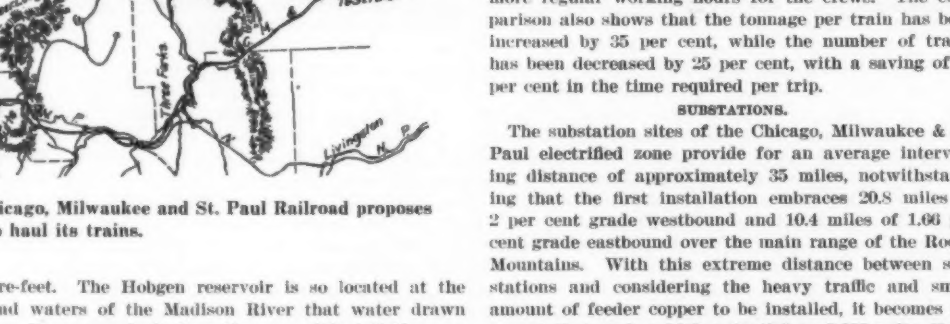
The substation sites of the Chicago, Milwaukee & St. Paul electrified zone provide for an average intervening distance of approximately 35 miles, notwithstanding that the first installation embraces 20.8 miles of 2 per cent grade westbound and 10.4 miles of 1.66 per cent grade eastbound over the main range of the Rocky Mountains. With this extreme distance between substations and considering the heavy traffic and small amount of feeder copper to be installed, it becomes apparent that such a high potential as 3,000 volts direct current permits of a minimum investment in substation apparatus and considerable latitude as to location sites.

The substations will be of the indoor type, transformers being three-phase, oil-cooled, and reducing from 100,000 volts primary to 2,300 volts secondary, at which potential the synchronous motors will operate. The transformers will be rated 1,800 and 2,500 kilovolt-amperes and will be provided with four 2½ per cent taps in the primary and 50 per cent starting taps in the secondary.

The motor generator sets will comprise a 60-cycle synchronous motor driving two 1,500-volt, direct-current generators connected permanently in series for 3,000 volts. The fields of both the synchronous motor and direct-current generators will be separately excited by small generators direct connected to each end of the motor-generator shaft. The direct-current generators will be compound wound, will maintain constant potential up to 150 per cent load, and will have a capacity



Map of the mountain country of Montana where the Chicago, Milwaukee and St. Paul Railroad proposes to use electric power to haul its trains.



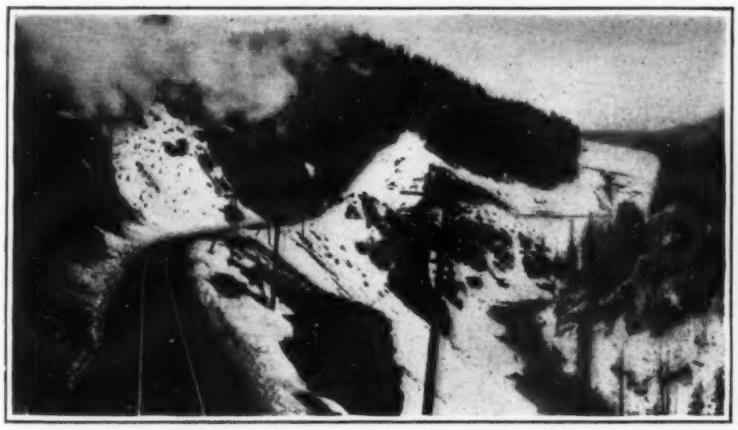
Profile of the route in above map, showing grades and distances.

Through Jefferson Valley, Montana.

Skirting the mountain tops, near Jefferson Valley.

Pulling over a heavy grade in the Rocky Mountains.

Tunnels and bridges in Sixteen Mile Canyon, Belt Mountains.



The east slope of the Bitter Root Mountains.

The devious trail through the Bitter Root Mountains.

On a two per cent grade in the mountains of Montana.

Raton Falls, which will supply part of the electric power.

SCENES IN THE REGION IN WHICH THE CHICAGO, MILWAUKEE AND ST. PAUL RAILROAD WILL USE ELECTRIC POWER.

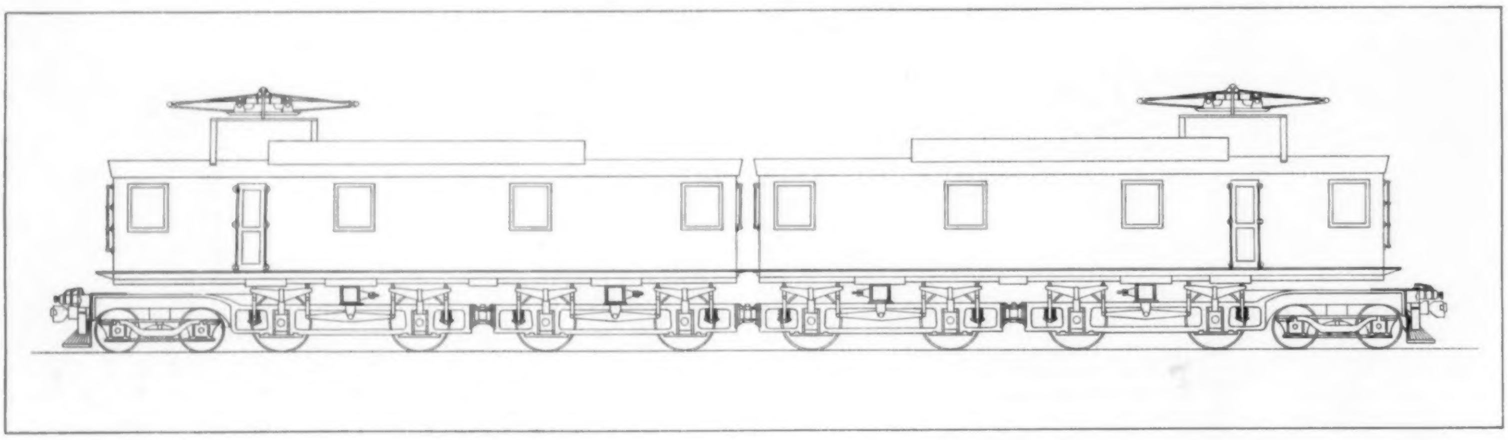
for momentary overloads up to three times their normal rating. To insure good commutation on these overloads, the generators are equipped with commutating poles and compensating pole-face windings. The synchronous motors will also be utilized as synchronous condensers, and it is expected that the transmission line voltage can be so regulated thereby as to eliminate any effect of the fluctuating railway load.

The location and equipment of the several substations is as follows:

Station.	Miles from Deer Lodge.	No. of units.	Kw. per unit.	Total.
Morel	17.1	2	2,000	4,000
Jancy	50.5	3	1,500	4,500
Piedmont ..	77.9	3	1,500	4,500
Rustis	120.6	2	2,000	4,000

OVERHEAD CONSTRUCTION.

The trolley construction will be of the catenary type, in which a 4/0 trolley wire is flexibly suspended from a steel catenary supported on wooden poles, the construction being bracket wherever track alignment will permit and cross-span on the sharper curves and in yards. Steel supports instead of wooden poles will be used in yards where the number of tracks to be spanned exceeds the possibilities of wooden pole construction. Poles for the first installation are already on the ground and thirty miles of poles are set. Work in this direction will be pushed with all speed and will be completed in the summer of 1915, ready for operation in the fall on the delivery of the first locomotives.



3,000-volt, direct-current electric locomotive. Most powerful yet built.

As the result of careful investigation and experiments, a novel construction of trolley will be installed, composed of the so-called twin-conductor trolley. This comprises two 4/0 wires suspended side by side from the same catenary by independent hangers alternately connected to each trolley wire. This form of construction permits the collection of very heavy current by reason of the twin contact of the pantograph with the two trolley wires, and also insures sparkless collection under the extremes of either heavy current at low speed or more moderate current at very high speeds. It seems that the twin-conductor type of construction is equally adapted to the heavy grades calling for the collection of very heavy currents, and on the more level portions of the profile where maximum speeds of 60 miles per hour will be reached with the passenger trains having a total weight of over 1,000 tons. The advantage of this type of construction is due partly to the greater surface for the collection of current, but largely to the very great flexibility of the alternately suspended trolley wires, a form of construction which eliminates any tendency to flash at the hangers either at low or high speed. Including sidings, passing and yard tracks, the 113 miles of route mileage is increased to approximately 168 miles of single track to be equipped between Deer Lodge and Three Forks in the initial installation.

LOCOMOTIVES.

The locomotives to be manufactured by the General Electric Company are of especial interest for many reasons. They are the first locomotives to be constructed for railroad service with direct-current motors designed for so high a potential as 3,000 volts. They will weigh approximately 260 tons, and will have a continuous capacity greater than any steam or electric locomotive yet constructed. Perhaps the most interesting part of the equipment is the control, which is arranged to effect regenerative electric braking on down grades. This feature as yet has never been accomplished with direct-current motors on so large a scale. The general characteristics as proposed are tabulated below:

Total weight	260 tons
Weight on drivers	200 tons
Weight on each guiding truck	30 tons
Number of driving axles	8
Number of motors	8
Number of guiding trucks	2
Number of axles per guiding truck.........	2
Total length of locomotive	112 feet
Rigid wheel base	10 feet
Voltage of locomotive	3,000
Voltage per motor	1,500
Horse-power rating 1 hour-each motor......	430
Horse-power rating continuous, each motor.	375
Horse-power rating 1 hour, complete locomotive	3,440
Horse-power rating continuous, complete locomotive	3,000
Trailing load capacity, 2 per cent grade.....	1,250 tons
Trailing load capacity, 1 per cent grade.....	2,500 tons
Approximate speed at these loads and grades	16 m.p.h.

The Chicago, Milwaukee & St. Paul Railway, from Harlowton to the coast, crosses four mountain ranges. The Belt Mountains at an elevation of 5,768 feet, the Rocky Mountains at an elevation of 6,350 feet, the Bitter Root Mountains at an elevation of 4,200 feet, and the Cascade Mountains at an elevation of 3,010 feet. The first electrification between Three Forks and Deer Lodge calls for locomotive operation over 20.8 miles of 2 per cent grade between Piedmont and Donald at the crest of the main Rocky Mountain Divide, so that the locomotives will be fully tested out as to their capacity and general service performance in overcoming the natural obstacles of the first engine division.

The initial contract calls for nine freight and three passenger locomotives having the above characteristics and similar in all respects, except that the passenger locomotives will be provided with a gear ratio permitting the operation of 800-ton trailing passenger trains at approximately 60 miles per hour, and will, furthermore, be equipped with an oil-fired steam heating outfit for the trailing cars. The interchangeability of all electrical and mechanical parts of the freight and passenger electric locomotives is considered to be of very great importance from the standpoint of operation and maintenance.

The cab consists of two similar sections extending practically the full length of the locomotive. Each section is approximately 52 feet long and the cab roof is about 14 feet above the rail exclusive of the housings for ventilation. The trolley bases are about 5 feet above the roof, owing to the unusual height of the trolley wire, which will be located at a maximum elevation of 25 feet above the rail. The outer end of each cab will contain a compartment for the engineer, while the remainder is occupied by the electric control equipment, train heater, air-brake apparatus, etc.

MOTORS.

The eight motors for the complete locomotive will be type G.E.-253-A. This motor has a normal one-hour rating of 430 horse-power with a continuous rating of 375 horse-power. The eight motors will thus give the locomotive a one-hour rating of 3,440 horse-power and a continuous rating of 3,000 horse-power, which makes it more powerful than any steam or electric locomotive ever built. The drawbar pull available for starting trains will approximate 120,000 pounds at 30 per cent coefficient of adhesion.

Each motor will be twin-geared to its driving axle in the same manner as on the Butte, Anaconda & Pacific, the Detroit River Tunnel, and the Baltimore & Ohio locomotives, a pinion being mounted on each end of the armature shaft. The motor is of the commutating pole type and has openings for forced ventilation from a motor-driven blower located in the cab.

The freight locomotives are designed to haul a 2,500-ton trailing load on all gradients up to 1 per cent at a speed of approximately 16 miles per hour, and this same trainload unbroken will be carried over 1.66 and 2 per cent ruling grades on the west and east slopes of the Rocky Mountain Divide with the help of a second similar freight locomotive acting as a pusher. Track provision is being made at Donald, the summit of the grade, to enable the pusher locomotive to run around the train and be coupled to the head end to permit electric braking on the down grade. In this case, the entire train will be under compression and held back by the two locomotives at this head end, the entire electric braking of the two locomotives being under the control of the motorman in the operating cab of the leading locomotive. It is considered that electric braking will prove very valuable in this mountain railroading; for, in addition to providing the greatest safety in operation, it also returns a considerable amount of energy to the substations and transmission system, which can be utilized by other trains demanding power. In this connection, the electric locomotives will have electric braking capacity sufficient to hold back the entire train on down grade, leaving the air-brake equipment with which they are also equipped to be used only in emergency and when stopping the train. There is, therefore, provided a duplicate braking system on down grades, which should be reflected in the greatest safety of operation afforded and the elimination of a considerable part of break-downs, wheel and track wear and overheating, with consequent reduction in maintenance and improvement in track conditions.

With the completion of the remaining engine divisions, it is proposed to take advantage of the possibilities afforded by the introduction of the electric locomotive by combining the present four steam engine divisions into two locomotive divisions of approximately 220 miles length, changing crews, however, at the present division points. As the electric locomotive needs inspection only after a run of approximately 2,000 miles, requires no stops for taking on coal or water, or layover due to dumping ashes, cleaning boilers or petty roundhouse repairs, it is expected that the greater flexibility of the locomotive so provided will result in considerable change in the method of handling trains now limited by the restrictions of the steam engine.

The electrification of the Chicago, Milwaukee & St. Paul is under the direction of Mr. C. A. Goodnow, assistant to the president and in charge of construction. The field work is under the charge of Mr. R. Beeuwkes, electrical engineer for the railway company.

Handling Freight by Motor Trucks

A FEW years ago an innovation appeared in the way of a motor-driven truck for handling baggage in a few large railway passenger stations, and since that time great progress has been made in adapting the system to the handling of freight, with the result that the cost has been very considerably reduced. An instance illustrating the advantage gained is the report of the experience of the Central Georgia Railroad in handling cotton between the piers and storehouses at Savannah, where by the old methods of hand labor the cost was a little over six cents per bale, which the electric trucks driven by storage batteries reduced to about two and one third cents. Portable motor-driven jib crane loaders were then added, and these brought the cost, including fixed charges, maintenance and cost of power, to about 2.2 cents per bale. This is a remarkable showing in view of the fact that the electric outfit is in use only about four months each year. By the use of the loader the trucks can be loaded at the rate of a 500-pound bale every twelve seconds, which is much quicker than hand loading, and can be kept up all day, which is not the case with hand labor. Besides the money saving effected by the use of electric power there is an additional saving in time.

Arithmetical Machines—I*

Their History, Theory and Methods of Construction

By H. E. Goldberg, M. W. S. E.

The first arithmetical machine was invented, as far as I know, by Blaise Pascal, about 1641. Pascal, you will recall, was the wonderful Frenchman, who at the age of sixteen, discovered the theorem in conic sections called Pascal's hexagram. He was not only one of the foremost mathematicians of his day, but also excelled in mechanics. At the age of 19 he produced the first machine with mechanical means for the carrying of the tens. Immediately the field of calculating machines became fertile ground, and many inventors cultivated it.

The next notable production was by Leibnitz, about 1671. He built several multiplying and dividing machines, and a good description of one, constructed about 1700—the first in which a multiplicand could be set up and preserved during the process of multiplication—is available. But this machine was never put on the market. In some of its features it resembled the Thomas machine of later years, which was a well-designed and well-constructed multiplying and dividing machine built by Thomas and marketed in Europe about 1820, and which is still in use.

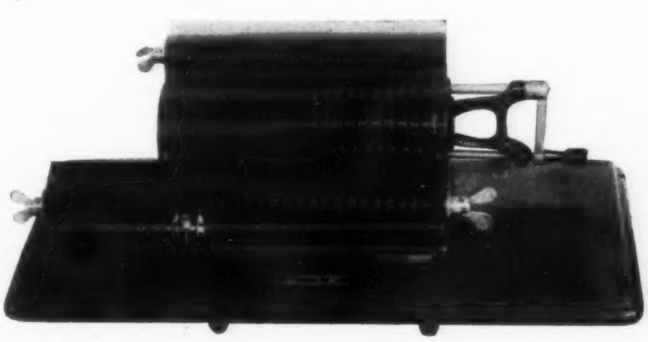
Up to that time inventors had been modest and were satisfied with making simply multiplying and dividing machines, but about 1825 Charles Babbage of England became bolder, and built a difference engine. Let me recall to you that the series of integral values of any as well as his own fortune, without completing any machine.

Another commercial advance we find in about 1878, when the Russian, Ohdner, put on the market the machine that is now called the Brunsviga, and is also marketed under the names of the Marchand, the Thales, the Triumphator, the Teitzgen, etc.

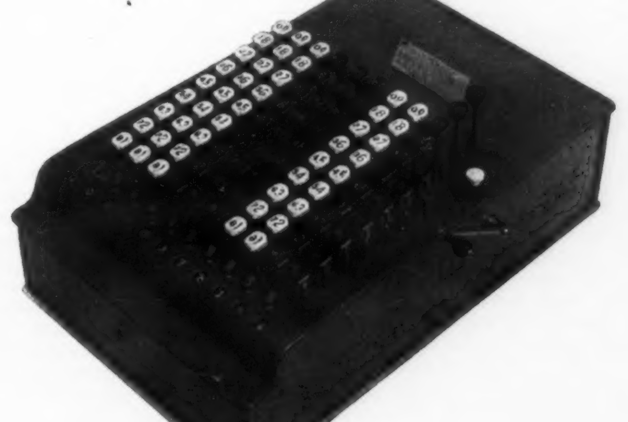
In this country, I believe the first patent on calculating machines issued by the Patent Office was to O. L. Castle of Alton, Ill., about 1850. It was for a ten-key adding machine, which did not print. It added in only one decimal column, helping a bookkeeper to add up, say, the units column of a long account. It could then be used for the tens, and so on. We find, quite early, key machines having a keyboard like the present Burroughs keyboard, namely 81 keys. Riggs, in America, shows such a machine about 1854. It is astounding how early some ambitious projects were launched. For instance, in 1871 we find that Teasdale invented a machine for multiplication. Suppose it were desired to multiply 4892 by 7926. Put the multiplicand and multiplier in the machine, turn the crank, and, presto, there is your answer! No such machine has yet been put on the market, although attempts have been made in that direction. About 1888 the first Burroughs machine, which both added and printed, appeared on the market. It was quite unlike the present type, which dates from cycles corresponding to ten, namely, totalizer wheels each provided with teeth some multiple of ten; for instance, the wheels have ten teeth, twenty teeth, thirty teeth, etc. (Let me state here that arithmetical machines calculating with Arabic numerals have been made without the numbers being represented on wheels. In fact, one machine, Mr. Bricken's, has no wheels whatever.) In totalizers where the number is supposed to be read off by the operator, it is customary to supply the wheels with the digits 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. In machines where the number on the wheels is not read by the operator, the digits are not supplied. For instance, the Burroughs has digits on its totalizer, while the Dalton has not.

What means are used in putting a number into an arithmetical machine?

Some machines, for instance the Triumph, are nothing but big totalizers; the totalizer wheels are so large that the operator has room enough to place his fingers through a window into the spaces between the teeth of the wheels. The machine is furnished with dials indicating where the operator is to place his finger for a 1, for a 2, etc. After properly locating the finger, the operator pulls it down as far as it will go, that is, until he strikes the bottom of the window. He thus rotates the engaged totalizer wheel one step, two steps, or any number that he desires. This is certainly the



Brunsviga machine



Comptometer

rational algebraic polynomial can be calculated by the method of differences. This is shown in algebra. It is true that many other functions, for instance logarithms, can be calculated by the same method of differences. The method will not apply throughout the whole series of logarithms, but does apply with sufficient accuracy for a group of a large number of consecutive terms. Thereafter a new start is made for another group. Babbage invented his machine, intending originally to apply it to the calculation of logarithms, as well as to the calculation of all sorts of nautical and astronomical tables. When he was about half through with his first or difference machine he decided that it was not good enough, and invented what he called the analytical engine—a calculating machine that could compute any arithmetical results that could be computed by a human being. For instance, it would extract square root, cube root, solve equations by Horner's process, and so on. However, this machine was never built. The principle on which it depended was similar to that of the Jacquard loom. Many of you have doubtless seen a machine, controlled by a series of cards pierced with holes, which weaves a portrait, say of George Washington. Babbage proposed to juggle with numbers in the same manner as the Jacquard loom juggles with threads. It was a most ambitious project, but was not fulfilled. I have read his book and studied some of his mechanisms. They are not as simple as they might be. Babbage claims, incidentally, that to meet the necessities of his work, he was the first to graduate the screws of the slide rests of his lathes. He spent a considerable sum of money advanced him by the government of England, about 1893. In 1888, we find the first typewriter attachment, invented by Ludlum. The Duplex Comptometer, invented by Dorr E. Felt, was put on the market about eight years ago.

Many patents on calculating machines have been issued by the Patent Office, and under the circumstances

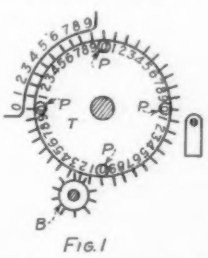


FIG. 1

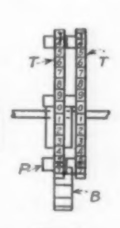


FIG. 2

it will therefore be impossible for me to refer to any more than a few of the mechanisms described. Moreover, for the purpose of convenience, the sketches which I have made are diagrammatic, and follow no particular machine.

Adding Machines.—Our system of numeration is a decimal system. We count in cycles of ten. After reaching ten, we start again to twenty, then to thirty, and so on. Of course, we have exceptions, namely, eleven, twelve, and thirteen. Logically, however, we should say ten-one, ten-two, and ten-three. While we are able to twist ourselves and our minds into all sorts of knots, mechanism refuses to be so accommodating, and in a decimal mechanism eleven is always ten-one and nothing else. We find that almost all arithmetical machines represent the number by mechanical most direct method, and was the one used by Pascal in 1641. Certain miniature machines working on the same principle have been built, but instead of using the finger, a pencil or sharp steel point called a stylus is placed through the window between the teeth of the wheels.

Let us put the number 132 into the machine. We place the finger in the 1 location of the hundreds wheel, and pull down. We then put the finger in the 3 place of the tens wheel, and pull down. And so on. The capacity of the machine is, of course, determined by the number of totalizer wheels, of which I have represented only two.

Carrying Mechanism.—Each totalizer wheel is supplied somewhere on its circumference with a variation which mechanically determines the location of the carrying point and which arithmetically corresponds to the 0. The first step away from the 0 is 1, both mechanically and arithmetically, the second step, 2, and so on. This variation on the totalizer wheel is ordinarily a projection like a pin, as in the Wahl, the Burroughs, the Brunsviga, and other machines. On the other hand, it may be, instead, a drop or fall, or a cut, as in the Howieson and other machines. Of the various carrying mechanisms possible I will now explain the principle of the one illustrated in Figs. 1 and 2. Something similar is used in the Wahl machine.

In the totalizer there are two sets of gears, the totalizer gears proper T, and the intermediate wheels B. Each totalizer wheel has, as shown in Fig. 1, forty teeth and a projection P to the left for each ten teeth. The number of teeth upon the intermediate wheels is of no importance. If one of the wheels T be rotated, then in due time its carrying projection P will engage

* A paper read before the Western Society of Engineers, and published in the *Journal* of the Society.

the co-operating wheel B, which will be turned, and which will thus turn one step the next higher wheel T to the left.

Let us mentally add the numbers 132 and 654. (Fig. 3, Ex. 1.) We start from the units and say 2 and 4 are 6; 3 and 5 are 8; 1 and 6 are 7. The answer is 786. In this particular example no carrying of the tens occurred. The process that did occur seems to have no universally accepted name, and I will term it accumulation. Take another example. (Fig. 3, Ex. 2.) Add 9999 and 1. Again starting from the units decimal place, we say 9 and 1 are 10, put down 0 and carry 1. We then go on, and in the tens decimal place say 9 and the carried 1 are 10; put 0 down and carry 1. In the hundreds again, 9 and the carried 1 are 10; put down 0, carry 1; and so on to the end, where we put down the last carried 1. The addition of the numbers 9999 and 1 requires practically nothing but tens-carrying. Let us take still another example. (Fig. 3, Ex. 3.) Let the two numbers to be added be 9999 and 9999. We say in the units place, 9 and 9 are 18; put down 8, carry 1; and so on. We see that in every decimal place from the units on there occur both accumulation and carrying. No new process is discovered. It will be found that addition is composed of only these two, namely, accumulation and carrying. Let us refer again to the third example. In the units place we say, 9 and 9 are 18; put down 8 and carry 1. In the tens place we say, 9 and 9 and the carried 1 are 19; put down 9 and carry 1; and so on to the end. Let me call to your attention that in this process we first accumulate, then tens-carry, then again accumulate, then again tens-carry, and so alternate one with the other to the end. That is, both the accumulation and the carrying are successive; each follows the other, and only one is done at a time.

Ex. 2	Ex. 3	
9999	9999	9999
1	9999	9
10000	19998	18999
		9
		19899
Ex. 1		9
132		19989
654		9
786		19998

FIG. 3

On account of the limitation of the human mind, we in school are taught to add by doing one thing at a time. In addition as shown above, we accumulate and tens-carry singly and successively. The Wahl totalizer, however, is not so limited. It carries in all the decimal places simultaneously, but accumulates in only one decimal place at one time, that is, successively.

Now consider the third example from the standpoint of this totalizer. The totalizer is supposed to have already absorbed the first number, 9999, and the following description of the operation deals with the process of absorbing and digesting the second number:

First, the totalizer receives (as before described) the 9 of the thousands place. This immediately mixes with the contents already in its stomach; namely, the first number. The bite is simultaneously digested, and the result is 18999. A second bite is taken, and digested during the swallowing. The result is 19899. The 9 in the tens place is swallowed, and the result is 19989; and when the last 9 has been absorbed the result is immediately 19998. In the second example it would make one bite of the 1 in the units place, carry simultaneously throughout all its decimal places, and be completely done.

Machines whose totalizers act as just described are found among the typewriter attachments, of which the Underwood Computer as well as the Wahl are examples. The first typewriter attachment patented by Ludlum in 1888 operated in the same manner.

Locking Mechanism.—The above is the principle of the carrying mechanism. In practice, many additional features are supplied, some of which I will point out. The quick movement of a wheel T will cause its projection P to strike the intermediate wheel B quite sharply, which thereupon will rotate the next higher wheel T, not only one step, as required, but perhaps several superfluous steps. A mistake will thus be made. To prevent such mistakes, locking mechanism is introduced. In the Wahl machine the locking mechanism is composed of Geneva gearing. This locking Geneva gearing in its turn requires unlocking mechanism, so that the final result is far more involved than the above sketch indicates. In the Underwood-Wright machine, which uses a similar carrying mechanism, overthrow is prevented by a set of spring pawls. These check the momentum of the flying wheels, but, of course, they also interpose a resistance against the free starting of the wheels, which in turn leads to motor mechanism to drive them.

You will notice that the above carrying mechanism is reversible. It will work just as well if the wheels T are rotated one way as the other. It, therefore, can be and is used for both addition and subtraction, subtraction being accomplished by rotating the gears T in the direction opposite to that for addition.

Figs. 1 and 2 show only two wheels T and only one wheel B. In practice there are totalizers with up to twenty wheels T and, therefore, nineteen wheels B. Please note that in order to function correctly, only one wheel T at a time can be used for the insertion of the number. Pulling all four wheels down at once to add 9999 to 9999, would result in a mistake. This is

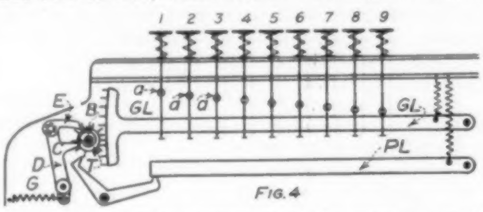


FIG. 4

because the carrying movement of the wheel B would take place at the same time as the accumulating motion of the wheel T and would thus be lost. To function correctly, all those wheels to the left of the particular wheel which is used for accumulating must be held in reserve in order to properly carry the tens. All the wheels to the right must be held non-interfering. Any carrying that does take place is, however, theoretically transmitted simultaneously throughout all the higher wheels to the left, and not successively as in the carrying mechanism to be described. The totalizer accumulates successively, but carries simultaneously.

Keys.—When we come to the subject of keys, we find two distinct and contending camps. There are what are called the 81-key machines and there are the so-called 10-key machines.

The keyboard of the 81-key machine is supplied with a number of banks of keys, say nine, each containing the keys 1, 2, 3, 4, 5, 6, 7, 8, and 9. There is a bank for the units decimal place, another bank for the tens, and so on. Notice that the zeros do not occur at all. In using such a machine the operator places his finger on the proper key in the proper decimal place, and pushes. For the number 1085 he places his finger on the 1 key of the thousands bank, on no key in the hundreds bank, on the 8 key in the tens bank, and on the 5 key of the units bank. He might operate with only one finger or with all the fingers; with the fingers one at a time or all together. Operators become expert on these machines, and I have seen them use sometimes the highest figure first and units last; again, units first and the highest figure last; and sometimes a mixed order. Among the machines that have 81 keys are the Burroughs, the Comptometer, the Comptograph, the Ensign, the Wales, etc.

The 10-key machines have no sets of banks of keys, but are provided with only one set of 10 keys; namely, 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9, and this set of keys is used for *all* decimal places. Here the 0 must be used. In writing a number like 11, the 1 key is struck twice. In writing 101, the operator would strike, in order, the 1, the 0, and again the 1 key. The most prominent 10-key machines on the market are the Dalton, the Moon-

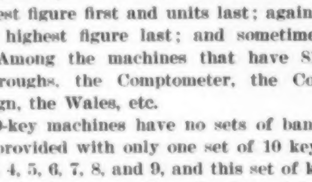


FIG. 5

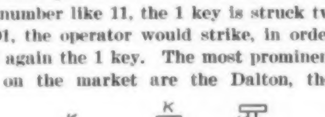


FIG. 6

Hopkins, and the typewriter-adding machines like the Wahl, the Elliott-Fisher, and the Underwood.

Keyboard adding machines can, however, be divided according to their construction into key-driven and key-set machines.

Key-driven Machines.—The simplest key-driven mechanism is one something like the old Comptometer. (You will pardon me if I do not describe the actual construction of any machine, for in that way I cannot so easily be caught in an error. Besides, in the actual machine, the mechanism occurs in several layers, which cannot be so readily understood as a diagram laying it out in one plane.)

Reference to Fig. 4 will show that there are as many banks of keys as there are decimal places. In each bank there are nine keys, to which are given the values 1, 2, 3, 4, 5, 6, 7, 8, and 9. Each key is normally kept up by a spring. Underneath them a lever GL is extended, with a gear attached thereto. Normally it is held up by a spring. There is another lever PL, which co-operates with a pawl, that can be inserted in a gear T, which is in chain with the gear upon the gear lever. When a key is pushed down, there occurs initially some lost motion; that is, the key does not strike anything. A little later a projection a on the key strikes the gear lever GL and moves it. Just when the gear lever has moved an amount corresponding to the value of the key pushed down, the bottom of the key strikes the pawl lever PL and pushes the pawl into the teeth of the gear T, thus preventing overthrow. The gear lever thus has been pushed down by a key a number of steps equal to the value of the key. Namely, the 1 key has pushed the gear lever down one gear step, the 2 key two gear steps, etc., before locking occurs. There is a ratchet mechanism (not shown) between the gear lever and the totalizer wheel T, so that on the way up the gear lever does not rotate the wheel of the totalizer.

The above is practically the mechanism of the Ludlum machine and of the old Comptometer. In the new Comptometer some modifications have been introduced. For instance, the gear lever does not rotate the totalizer wheel on the down push of the lever, but on the return thereof. Again, there are two pawl levers, instead of one, permitting the making of a portion of the mechanism twice as large and therefore stronger.

In the old Comptometer, the carrying mechanism upon the wheels T was something as follows: (Fig. 4.)

Each totalizer wheel T was supplied with a cam B, which gradually extended further and further from the center, and which was provided with a sharp drop at one point. The drop was located at the point corresponding to 9. The cam co-operated with a tooth C on a lever D. The lever had at its outer end a pawl E, which could drive a ratchet wheel on the next higher wheel T. As the lower wheel T rotated, its cam gradually pushed back the lever D, storing energy in the spring G. When the drop of the cam B passed under the tooth of the lever, the latter was no longer resisted, whereupon it flew in, and by means of its pawl E pushed the next higher wheel forward one step. This carrying mechanism is irreversible; that is, it will not work if the wheel T rotates in the opposite direction; it accumulates successively and carries successively. It was used in the Comptometer, the Dougherty, the Fisher, and the Howieson machines. In the present Comptometer a modification of this older carrying mechanism is used, which still employs the cam and sudden drop.

Full-stroke Mechanism.—Let me call your attention to the fact that in the above machine, if the operator incompletely depresses any key, he will turn the totalizer wheel an insufficient amount. He will thus register a mistake in the machine. Such is actually the case with a good many machines on the market; for instance, the Burroughs non-listing machines. To prevent such a mistake, various mechanisms called "full-stroke" have been provided. They operate about as follows: (Fig. 5.)

Let K be a key with teeth on its edge. Let B be a pawl which by means of a spring C always tends to return to its central position if displaced. Obviously, the key can now move down, but the moment its teeth engage the pawl the latter swings down, assuming a position as drawn at C^1, and prevents the key from rising. However, when the ratchet has moved completely past B, then the latter snaps up and the key is then free to move up again. Full-stroke mechanism is in use on the handles of many adding machines, for instance the Burroughs. It is also in use on multiplying machines such as the Brunsviga. Something similar is used as a part of the full-stroke mechanism of the keys of the Wahl.

Single-key Mechanism.—There are other troubles that are encountered in the operating of the keys. Suppose the operator inadvertently strikes two keys at once. What happens? In some machines, in fact in most machines, the result is a mistake. In others, the Wahl, for instance, it is impossible for the operator to depress two keys at once. This is prevented by what is called a single-key mechanism, constructed somewhat as follows:

Let A^1 and A^2 (Fig. 6) be the cross-sections of two key levers of a typewriter. Hanging between the key levers are some pieces B^1, B^2, B^3, whose width is equal to the distance between the centers of the key levers. On the outside of all the pieces B are two stops C^1 and C^2. The pieces B occupy all the room between the stops except the thickness of one lever A. Thus if one lever, say A^1, be depressed, it shoves B^2 and B^3, etc., to the right and B^1 to the left, and then continues without any interference. Should the attempt be made to shove two levers down simultaneously, they jointly take up too much room, and, therefore, both get jammed. The single-key mechanism is extensively used, not only on adding machines, but in cash registers and voting machines. Some of you must have wondered how it is that in the Chicago voting machines it is possible to vote for, say, only 10 out of 150 candidates. It is by an extension of the above mechanism.

(*To be concluded.*)

The Fluorescence of Petroleum Distillates*

By Benjamin T. Brooks and Raymond F. Bacon

FLUORESCENCE is one of the most striking characteristics of petroleum distillates, but its cause is not known, at least some of our best authorities attribute it to causes which have nothing to do with the phenomenon. The heavier distillates from Pennsylvania and certain other crude petroleums have a marked greenish fluorescence, and the trade has come to associate this property with Pennsylvania oils. For some uses it is common practice to "debloom" the oils by sun-bleaching or by the addition of certain "deblooming" substances. The subject therefore has some practical as well as theoretical interest.[1]

Engler considers that the fluorescence of mineral oils is due to their colloidal character. Crude oils and the heavier distillates are optically nonhomogeneous and show a marked Tyndall effect, but this property cannot be considered as indicating colloidal properties since many organic compounds having large molecular weights show the Tyndall effect when in true solution. Schneider and Just[2] claim to have observed ultramicroscopic particles in a "yellow mineral oil" and a sample of "paraffine oil" Holde,[3] studying the physical condition of lime soaps in grease, stated that colloidal particles are not discernible as such under the microscope. It is probable, however, from the researches of Holde that such greases, as well as oils containing asphaltic or resinous matter, are to be regarded as colloidal, not *true* solutions. Schulz[4] claimed that the effect of adding "deblooming" substances, such as nitrobenzol and nitronaphthol, was merely that of adding something having a high refractive index, thus making the oil optically homogeneous.

This theory of fluorescence of mineral oils seemed very plausible. However, since many examples of nonfluorescent oleo-resinous solutions and mixtures are known, and since the fluorescence of mineral oils persists after repeated distillation and is quite marked in distillates boiling as low as 200 deg. Cent., we believed that resinous or asphaltic matter could not be a contributing factor. Our experiments have shown that, in general, oxidizing agents partially or wholly destroyed the fluorescence. Certain facts suggested to us that sulphur or carbon in colloidal suspension might be the cause of the phenomenon. Stable colloidal suspensions of carbon in water and various organic liquids have been prepared[5] and described as nonfluorescent and brown to black in color. Sulphur, on the other hand, often shows bluish colors when in colloidal degree of dispersion, and the blue color of ultramarine blue is undoubtedly caused by so-called colloidal sulphur.[6]

We have succeeded in proving that colloidal suspensions have nothing to do with the fluorescence of mineral oils.

Working on the theory that ultramicroscopic particles were present, 100 cubic centimeters of a highly fluorescent lubricating oil were diluted with kerosene to about 500 cubic centimeters in order to decrease the viscosity. The solution was placed in a suitable cell containing two round copper plates spaced 2 centimeters apart. The oil between the plates was subjected to a unit direction field of 30,000 volts potential difference for 30 minutes without any visible change in the fluorescence or flocking out of any kind of substance.

A sample of the same solution, carefully dried by calcium chloride, was filtered through the finest filter paper and examined under an ultramicroscope of the Zsigmondy-Siedentopf type, but no particles whatever were visible. It was found that unless the oil was carefully dried and filtered particles were visible in the light cone. These may have been minute drops of water or dust. The fact that the ultraviolet light cone is made visible to the eye with bright fluorescence has no significance so far as the colloidal theory is concerned, since as a general rule the wave length of the emitted fluorescent light is always greater than the incident ray, in this case from ultraviolet to visible blue. Furthermore, the ultraviolet cone contains a certain amount of the visible rays. No more rigid proof of the nonexistence of substances in colloidal suspension in carefully purified fluorescence mineral oil could be desired. In order, further, to test the arrangement and efficiency of our instrument, a colloidal gold "solution" was made by the formaldehyde reduction method, one of platinum by the Bredig method, and one of palladium by reducing with hydrogen according to Paal, and the beautiful results characteristic of this instrument were obtained.

Percolation through Fuller's earth is an excellent and well-known method for clarifying and bleaching oils. A sample of a highly fluorescent lubricating oil was allowed to run through a 5-foot tube packed with fine Fuller's earth. The resulting oil was very light in color but highly fluorescent, and when a little tarry matter, which gave brown nonfluorescent solutions in kerosene, was added to the oil until the color matched the original oil, the two could not be distinguished. The fluorescent material is therefore only slightly absorbed by Fuller's earth, and is probably not of very great molecular complexity.

While working on the colloidal suspension theory, the marked solubility of sulphur in mineral oils was noted. A 200 cubic centimeter sample of a light machine oil was heated to 100 deg. Cent. with an excess of flowers of sulphur, filtered hot, and on cooling about 0.5 gramme of sulphur crystallized out. Guiselin[7] states that benzine dissolves 0.5 per cent sulphur at 20 deg. Cent. It is extremely improbable that a *stable* colloidal suspension could exist in which the solubility of one phase in the other is as great as in the case of sulphur and petroleum oils.

Carbon disulphide added to a fluorescent lubricating oil weakens the fluorescence almost to the point of extinction; what remains is dark greenish. Before making the experiments with the ultramicroscope, this was thought to favor the sulphur suspension theory, or the theory of Schulz based on optical homogeneity.[8]

Further experiments with other solvents showed that the character of the fluorescence was affected by the various common solvents in the same way as in the case of the diamino derivatives of terephthalic acid methyl esters, studied by Kauffmann.[9] The effect of the various solvents was even more marked with solutions of the purified fluorescent material described below. The fluorescence colors observed were as follows:

Amyl alcohol	Brilliant sky-blue
Aniline	Very faint green, no blue
Benzol	Pure clear blue
Carbon disulfide	Faint green, no blue
Chloroform	Bluish green, passing into green on concentrating
Ether	Clear blue
Ligroin	Blue
Phenol	Greenish blue
Pyridine	Bluish green

In most cases the addition of *small* amounts of solvents having high refractive indices has practically no effect on the fluorescence. The effect of adding nitro compounds therefore must have an explanation different from that offered by Schulz.

The introduction of a nitro group into the molecule of a fluorescent benzol derivative, such as the terephthalic esters, completely destroys its fluorescence. It appears that a nitro group in the solvent has the same effect as a nitro group in the molecule of the active compound itself. This is not surprising in view of the marked effect of other solvents. We believe that possibly the fluorescent substance in mineral oil owed this property chiefly to the presence of one or more amino groups as auxochromes but, as will be shown below, this cannot be the case. Although we have found that oxidizing agents destroy the fluorescence, it is probable that the action of nitro compounds is purely physical since we have added N^2O^4, nitrated kerosene or nitrobenzol to fluorescent lubricating oils chilled to —10 deg. Cent. and destroyed the fluorescence. It is highly improbable that oxidation of any hydrocarbons could take place under these conditions since at 0 deg. Cent., N^2O^4 merely adds on to ethylene bonds without oxidation.[10] There is also the possibility that such compounds as picric acid and nitrobenzol form nonfluorescent addition products, or double compounds, such as is the case with pyrene and chrysene. However, the simple nitro paraffines are not known to form such double compounds, and "nitro kerosene" is fully as efficacious as nitrobenzol for neutralizing fluorescence. The following experiment is interesting in this connection: A sample of a highly fluorescent lubricating oil was "debloomed" by the addition of nitrobenzol. This oil was then shaken out six times with one-half its volume of 96 per cent alcohol, after which treatment the blue fluorescence had reappeared and exactly matched a sample of the same oil not treated with nitrobenzol, but shaken out with alcohol in the same way as the first sample. Refining such a "debloomed" oil with sulphuric acid yields a fluorescent oil identical in this respect with that obtained by refining the original oil. The action of nitro compounds in neutralizing fluorescence must, therefore, be purely physical in character.

The fact that exposure to the atmosphere for some time partially destroys and changes the character of the fluorescence suggested that what took place during this process was slow autoxidation.

Nitrous acid readily neutralized the fluorescence of lubricating oils, but the oils gradually became dark colored and resinous. Distillation of the latter dark colored oil *in vacuo*, or with superheated steam, yielded oil having a bluish fluorescence. Repeated washing with alkali removes only a small part of the coloring matter. Shaking a part of a sample of pale engine oil with nitrous acid for 3 minutes, followed by washing with water and filtering through Fuller's earth, gave a less resinous, light colored oil, very similar to that obtained by sun-bleaching. Oxides of nitrogen, generated by the action of dilute nitric acid on a metal, were then tried, and it was found that the sun-bleached oil could be matched with respect to color and fluorescence, provided the temperature of the oil was not permitted to rise above 10 deg. Cent. before washing with dilute alkali. At low temperatures addition of oxides of nitrogen to unsaturated compounds probably results as shown by Jegorow. Unless the oil is chilled before passing in the oxides of nitrogen oxidation appears to result, accompanied by rise in temperature, darkening in color and formation of resinous material. No method of removing the resinous coloring matter without at least partially restoring the bluish fluorescence was found. The effect on the color of the oil of nitric acid in sulphuric acid, when used for refining, is well known and constitutes one of the advantages of acid made by the contact process over that made by the chamber method.

We then made a series of experiments to determine the chemical properties of the fluorescent substance. The efficiency of sulphuric acid, particularly fuming acid, in removing fluorescence is well known. It was found that the wash water from freshly prepared acid sludge tar, made by refining lubricating stock, was highly fluorescent. This suggested that the fluorescent material formed water-soluble sulphonic acids, or that the fluorescent substance was a base and removed as a soluble sulphate. The latter hypothesis can hardly be true since dilute acids do not exact the fluorescent material from the oil. A quantity of such fluorescent aqueous solution was made alkaline and extracted with ether, but no fluorescent material was obtained, indicating that the substance in question is not a base. A dilute acid solution of the fluorescent substance was nearly neutralized with lime to remove the excess of sulphuric acid. The filtered aqueous solution was evaporated nearly to dryness and the crystalline residue, containing sulphate of lime, extracted with alcohol. Twelve liters of lubricating distillate yielded in this way about 1 gramme of an impure crystalline residue which was intensely fluorescent when dissolved in the different solvents named above. The amount obtained was too small to be thoroughly investigated, but we hope that we shall have an opportunity in the near future to prepare a quantity of this highly interesting material sufficient for further work. The above results were enough to show the general character of the substance. The crude fluorescent substance probably contains one or more compounds of the benzine series resembling, or perhaps identical with, chrysene, fluorene or pyrene. Such compounds are known to be formed by the pyrogenic decomposition of many organic substances. Klaudy and Fink, in 1900, isolated a yellow crystalline substance, giving highly fluorescent solutions, from the residuum of a cracking still. They give it the formula $C^{24}H^{18}$.

A large proportion of the fluorescent substance or substances is formed during the distillation of the crude. This was shown by distilling a sample of Oklahoma crude at atmospheric pressure and under a pressure of 5 millimeter of mercury. The distillates in the first series were very much more fluorescent than the latter. This is also true of the distillates from coal when distilled at atmospheric pressure and under a pressure of 5 millimeters. Parallel with this difference it should be noted that substances of the benzol series form a much greater proportion of the coal tar obtained at ordinary pressures, paraffines and olefines constituting over 80 per cent of the coal tar obtained by distilling *in vacuo*. It is also well known that no fluorescent substances are known belonging to the paraffine series.

Halogenation destroys the fluorescence, as is to be expected. Hydrogenation also destroys it.

* Presented at the 49th Meeting of the American Chemical Society, Cincinnati.

[1] Cf. "Relations between Physical Properties and Constitution," Kayser, "Handbuch d. Spectroscopie," Vol. IV., p. 839; Kauffmann, "Beziehungen zw. Fluoreszenz u. Chem. Konstitution," *Samml. Chem. u. Chem.-tech. Vorträge*, 11, 1906.

[2] *Z. f. wissensch. Mikroscopie*, 1905, p. 489.

[3] *Z. f. angew. Chem.*, 31 (1908), 2138; *Koll. Ztschr.*, 3 (1908), 270.

[4] *Petrol. Berl.*, 5, 205.

[5] Thomae, *Koll. Ztschr.*, 11 (1912), 268; Vanzetti, *Koll. Ztschr.*, 13, (1913), 6.

[6] Liesegang, *Koll. Ztschr.*, 7 (1910), 307; Hoffmann, *Chem. Ztg.*, 1910, p. 1,079.

[7] *Petroleum*, 1913, p. 1,309.

[8] The refractive index of carbon bisulfide is N_D-20°—1.6276.

[9] *Ann. d. Chem.* (Liebig—, 393 (1912), 1.

[10] Jegorow, *J. prakt. Chem.*, 86 (1912), 512.

Cement from Beets

It is now reported that a French firm is making an excellent cement from a by-product in the process of making beet sugar. The scum that forms when the beets are boiled, and which has heretofore been thrown away, consists largely of carbonate of lime and water, and from 70,000 tons of beets treated 4,000 tons of carbonate lime is obtained; to this 1,100 tons of clay is added, the resulting product being 3,162 tons of excellent cement. The scum is pumped into large tanks, where it is allowed to dry partially; finely divided clay is then mixed with it; the mixture is thoroughly amalgamated by beaters for an hour and burned in a rotary kiln, much in the same way as Portland cement. The clinker is then removed and pulverized into cement.

"Suction" Between Passing Ships—III*

Important But Little Understood Forces Affecting the Motion of Vessels

By Sidney A. Reeve, M. E.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2037, Page 48, January 16, 1915

IV. ACTUAL INSTANCES OF "SUCTION" COLLISION.

The following descriptions are condensed from the records of the American Admiralty courts. Usually the quotations are from the decision handed down by the court, summing up and balancing the conflicting testimony. Wherever possible, charts of the date of the collision have been consulted.

Case 6: "Andus"-"Saratoga," September 21, 1877, Hudson River, near Albany (Fig. 12). A southbound tow, consisting of eleven barges, banked three abreast, was moving parallel with the "dike" (really a wharf, the true dike being on the opposite side of the river). The steamer "Saratoga," 300 feet by 66 feet, also southbound, undertook to pass between the tow and the wharf. When the bow of the S had overlapped the aftermost barge some 40 feet "the tow sagged down with the wind (which was westerly, but very light) against the S." The court held that the wind theory was not upheld by the facts, and hence disbelieved that the "sagging" occurred at all. The term "suction" was not mentioned, but in the light of later knowledge it is a clear case. The courses are such that a shoaling of the water from 14 feet to 9 feet occurs just where the wharf also converges on the courses. The vessels probably had a draught of about 6 feet, and their aggregate beam amounted to nearly the width of the channel. Under such conditions suction was inevitable. But its hydraulic theory in this case falls more under that of "canal-waves" than of two-dimension stream-lines, which former the student will find discussed in the references listed in the first article of this series, page 31 *ante*.

Case 14: "Aurania"-"Republic," September 19, 1885, 3.24 P. M., 2 miles northeast by east of Sandy Hook (Fig. 13). This is the first recorded suction collision between first-class liners. In fine weather, with sea smooth, tide flood and wind light, the A (480 feet by 56 feet by 26.5-feet draught, 14.7 knots) and the R (420 feet by 42 feet by 25.2 feet draught, 13.2 to 13.5 knots) collided as they were about to enter Gedney Channel, the stem of the R striking the port quarter of the A when the latter's stem was about 100 feet west of the buoy (double circle in Fig. 13). The A had come down the (old) Main Ship Channel, and the R down Swash Channel. Each vessel headed for the buoy. There is the usual conflict of testimony as to locations and courses, but the agreement is closer than usual. The court concluded that the ships were on courses converging by 1½ points, as drawn; but this conclusion disregarded the R's claim as to angles and distances, because at a distance of 500 feet to 700 feet apart, one minute before the collision, "no possible suction, port helm or other influences from the A could have had any sensible effect upon the R at that distance, or have sensibly neutralized or delayed the effect of the hard-a-starboard helm, which her officers say the R was then under, and in spite of which, as they say, the vessels came together." But had the court been equipped with an adequate theory of suction the decision would probably have been reversed. The court was misled by the idea that suction is a force drawing the two hulls bodily together, whereas it is almost wholly a sheering or swinging pair of forces, one attracting the bow and the other repelling the stern. It is the forward momentum of the pivoted vessel, and not the attraction of suction, which brings her into the other ship. Thus, in this case, the R was traveling at about 1,350 feet per minute. According to the court's theory, the point of collision was only some 170 feet to starboard of the R's course. At her rate the suction-sheer need have been through an angle of only two points, beginning one-quarter minute before the impact, to have cleared the space between the two vessels, and at its inception the ships would have been only 400 feet or 500 feet apart. "Most of the witnesses on both sides seem to agree that shortly before the collision . . . the stem of the R seemed to be approaching the A's quarter more suddenly and rapidly than their previous angle of convergence would account for. . . . The evidence leaves no doubt that the R's engines were stopped and reversed just prior to the collision." The court, knowing that the R carried a hard-a-starboard helm, and finding no other explanation, attributes the sheer to the 4-mile breeze! Navigation would be hazardous indeed if a 4-mile breeze could entail such a disaster.

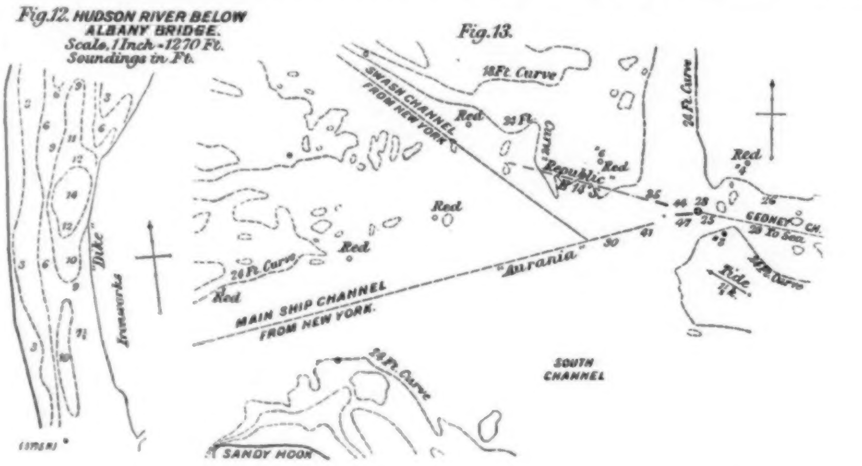
Fig. 13 (from a chart of 1884) shows that the water was shoaling rapidly beneath the A, at the rate of 15 feet in a ship's length, at the time and place of collision. This, coupled with the convergence of courses at an angle variously stated as from 16 degrees to 38 degrees, was undoubtedly the cause of the overwhelming suction. Although an unknown depth of tide must be added to the soundings of the diagram, the ships were drawing most of the water to be had beneath the A's stem. Had they met a minute later, over a flat sea-bottom, they would probably have escaped disaster. This same locality became the scene of another suction collision (case 35) between sea-going liners, but at a later date, when dredging had deepened the shoal spots.

Case 17: "Hartt"-"City of Brockton," September 29, 1887, outside Sandy Hook. The B (paddle-steamer 283 feet long) overtook the tug H (125 feet long) as both were going to an international yacht race. When Sandy Hook was passed and South Channel reached (see Fig. 13), at about the time when the paddle-box of the B was abreast of the pilot-house of the H, the latter "gave a sudden lurch towards the B, which shortened the distance between the two about one-third. The H then straightened up. Then she lurched again toward the B, and instantly the collision occurred, . . . the bow of the H striking first the port paddle-box of the B and then running under the B's port guard, where . . . . she was near being capsized, most of her passengers being thrown into the sea." The movement of the H is described by "Mr. A" as a "lurch." "It wasn't a case of gradual converging." Another calls it, "a grand swoop right around." Another says, "she made a dive for us." The court attributed the action to "the powerful action of the B's wheels," but hydraulic theory finds complete explanation in the interaction of the H's constrained wave with the B's echelon waves. The latter are independent of the ship's model, their length depending only upon the speed. The B's speed is stated as "14 to 15 miles." At 14 knots its echelon wave would be 109 feet from crest to crest, and at 15 knots 125 feet. It is plain that the H's constrained wave must have had a length suitable for interaction with the B's echelon. As one echelon crest came into phase the H took its first lurch. As the next crest came into phase the second lurch occurred. It is not likely that the sea-bottom was a contributing cause, though there are banks about 20 feet deep in this vicinity, which may have helped.

Case 18: "Switzerland"-"La Gascogne," January 21, 1888, New York Upper Bay; both vessels bound to sea; water 60 feet to 75 feet deep. In clear daylight, with no other vessels interfering, the L G (480 feet by 52.3 feet, 7,415 tons gross, 15 to 16 knots), "having come up with the S (329 feet by 38.8 feet, 2,601 tons, 9 to 10 knots), was passing her on the port side at a distance estimated by various witnesses at 150 feet to 300 feet. The bow of L G had drawn ahead of the bow of the S when the vessels came into collision, the S's bow striking L G on her starboard quarter at an angle of about 30 degrees. The lower court held the S at fault, but the upper court reversed this. Both courts, in order to develop a consistent explanation in lack of true hydraulic theory, were forced to disregard some well-founded evidence. But with suction properly in mind no violence to the facts is needed. The L G had to port somewhat at this point in the channel, and a very slight convergence of the two courses, if not noticed immediately by the S, would bring the latter into control of suction very quickly. Collision might occur from this cause within 43 seconds from an original distance of 250 feet, or in 26 seconds from 150 feet, if the L G's porting had been only one point.

Case 20: "Devereaux"-"Folsom"-"Mitchell," August 13, 1890. This was the first case in which the court considered suction as a cause when the vessels were passing in opposite directions. It occurred in a dredged channel between Lakes Huron and Michigan, about 300 feet wide by 25 feet deep. The D (270 feet by 37 feet) passed at 4 knots the tug F (185 feet by 35 feet), and sheered enough, uncontrollably, as she did so, to collide with the schooner M in tow of the F. The tendency of every ship to "smell" a bank and sheer away from it was mentioned in the decision; and it is certain that this tendency would be exaggerated at the moment the F passed.

Case 21: "City of Macon"-"Nedjed," December, 1890, Savannah River; a variation of the preceding case. When the M (about 300 feet long) was partly lapping the N (320 feet by 45 feet by 19½ feet draught), about 100 feet away in a channel 400 feet to 450 feet wide by 20½ feet deep, the N sheered across the M's bows, away from the wharves, and ran in the mud-bank opposite.



Case 24: "Mather"-"Ohio"-"Siberia," in daylight, date not stated, Mud Lake, St. Mary's River, Great Lakes. Mud Lake is virtually open water, being 3 miles wide by 25 feet to 30 feet deep for 100 feet to 300 feet on either side of the course. The M (260 feet by 15 feet draught) had overtaken the S (274 feet by 15 feet draught) about 40 feet to 75 feet away on the latter's starboard hand. The O was meeting the S port to port. When the M was about a half-length in advance of the S the latter "sheered suddenly to port, and within less than 60 seconds struck the O," and sank her. "The evidence seems to leave no reasonable doubt that when the effect of suction began to be noticeable these boats were within 40 feet to 75 feet of each other, and that the stern of the M was about abreast of the forerigging of the S. At this point it is in evidence from both sides that the speed of the S seemed to be increased, and that she ran up on the M some 10 feet or 15 feet. Yet it is uncontradicted that the steam of the S was not increased. This temporary increase of speed by the slower boat is shown to be one of the effects of suction. . . It has been argued that, if suction had exerted any force upon the navigation of the S, it would have shown its effect by attracting or drawing her closer to the vessel within whose influence she was, and not as a repulsing force throwing her off to port. But evidence of just such an attractive force appears." Evidence is then quoted by the court tending to show that the S was first drawn in towards the M, and then, later, whether assisted by a starboard helm or not is not known, sheered off toward the O. The facts emphasize the instability of steerage under such conditions. Perhaps a hard-a-starboard helm was assumed when the first sign of suction appeared, and this, after steadying her against the suction, carried her too far to port for her to recover within the 30 seconds available before she met the O. Or the lack of testimony as to the helm of the S might suggest a jammed helm. In any event suction was plainly the original cause of the disaster.

Case 25: "Aureole"-"Willkommen," January 13,

* Reproduced from *Engineering*.

1898, 2 P. M.; Delaware River, about 1 mile down Deep-Water Point range, with apparently ample room laterally, but very little depth. The bottom is even, but the charted depths are everywhere less than the draught of either ship; tidal depth not known. The A (345 feet by 46 feet by 23.5-25 feet draught) overtook the W (325 feet by 41 feet by 22.5-24.5 feet draught) on the latter's port hand, passing at distances variously stated as from 75 feet to 300 feet, the court favoring the smaller distance, as from more reliable witnesses. "Before the A's bow was opposite the W's bridge, the W's pilot ordered the wheelsman to port the helm . . . because he saw the A was coming too close. When the A's bows got abreast of the W's bridge, he says he told the captain to slow the ship to half-speed, and that when her stern got somewhere about half way between the W's fore-rigging and the bridge he had the engine stopped; that he then asked if the wheel was a-port, and that the chief officer replied that it was hard-a-port; that he then went and looked himself, and found that it was so, and that the A was at that time about 75 feet to 100 feet away." When the A's stern came forward of the W's bridge the W took a sheer and struck the A a glancing blow upon the starboard quarter about 35 feet from the stern. "This sheer of the W the pilot accounts for by what he calls 'suction.'" Both vessels had to return to Philadelphia.

The court referred to the cases of the "Folsom," the "Cleveland," the "Unit," the "Mariel," and the "Brockton." "The cases above referred to, judicially recognizing the existence of the force called 'suction' and its power under favoring circumstances, to draw one vessel towards another, cannot be disregarded by this court."

Case 26: "Masaba"-"Smith"-"Aurania," "on a bright July day in 1898," in the dredged channel in Lake St. Clair, above Detroit. In 1898 the St. Clair Channel was 350 feet to 400 feet wide by 20 feet deep, the Detroit channel 800 feet wide, and of equal depth. As it is not stated just where the collision occurred, both widths are given in Fig. 14, which is drawn to scale as to the lengths of the ships and tow-line, but not as to lateral distances, which are unknown. The case is cited as an interesting one of three-ship action, which is plainer from the diagram than from the description. The S was apparently not affected by the M until the "Aurora" was met, although the first two had been traveling at not widely differing speeds. The S recovered from her first sheer, apparently caused by her bow entering the "Aurora's" lateral depression, but took a second and uncontrollable sheer just after passing the "Aurora." "The 'Aurania's' helm was hard-ported, and the 'Aurora's' engine stopped, and the lever controlling the towing-machine on the 'Aurora' released so that the cable might reel out, there being no time or opportunity to let go the line on either vessel; but so extreme and rapid was the sheer of the S that she struck the towline at nearly a right angle, about 100 feet ahead of the 'Aurania,' parted the wire cable, and then swung around the bow of the 'Aurania,' which struck the S on the starboard quarter. The vessels came together with great force, driving the bow of the A to port and straightening the S up in the channel, so damaged that she filled and sank after going a short distance; while the A, with bows badly stoved, forged ahead and drifted diagonally down and across the channel until she brought up on the bottom, aided in this by a stern anchor which she had let go."

Case 35: "Martello"-"Mesaba," September 22, 1900, 10.42 A. M., New York Lower Bay, entrance to Gedney Channel, Fig. 13, but by this date dredging had reduced the slope of the bank to about 10 feet in a ship's length. Nor is the place of collision so exactly located as in the case of the "Aurania"-"Republic." An ebb-tide of 1 knot was with the ships. Both ships went down the old Main Ship Channel. They passed Sandy Hook with the "Martello" (370 feet by 43 feet by 28 feet draught, 10 knots) said to be one-third mile ahead of the "Mesaba" (482 feet by 52 feet by 29½ feet draught, 13 knots); but if this gap was closed by the time they reached Gedney there could have been a difference of only about 2 knots in their speeds. While the "Mesaba" was passing the "Martello" on the northern side, "probably from 100 feet to 150 feet" distant, "when the 'Martello's' stem was about abeam of the 'Mesaba's' amidships, or a little more aft, the 'Martello's' bow was seen to turn to port toward the 'Mesaba,' and it continued to turn more rapidly as the 'Mesaba' advanced, until the bluff of her port bow, about 20 feet from her stem, struck the starboard quarter of the 'Mesaba,' about 100 feet forward of her stern, a violent blow. . . . The 'Martello' was obliged to return to New York, while the 'Mesaba' continued her voyage." The court held that suction was the cause of the collision.

Case 37: "North Star"-"Nourmahal," September 28, 1901, 4 P. M. Swash Channel, New York Lower Bay (Fig. 13, just beyond the northern edge of which, where the eastern bank of Swash Channel is steeper, the collision occurred). The yacht N (247 feet by 30 feet by 10 feet to 16 feet draught, 15 knots) was overtaken on her starboard hand by the N S (320 feet by 46 feet by 13 feet to 15 feet draught, 17 knots). When the yacht was about 600 feet ahead of the N S they were "apparently something more than 100 feet apart, but were drawing slightly nearer, and when the N S's stern reached a point about opposite the bridge of the yacht, the latter, being influenced by the N S's suction, turned towards her, and the vessels came together, notwithstanding a starboard then hard-a-port helm on the part of the yacht. . . . There was no change in the course of the N S. . . . The collision can be accounted for in no other way than as a result of suction." The N S was held solely at fault.

Case 39: "Denver"-"Lehigh," March 31, 1906, 5.15 P. M., New York Lower Bay, below West Bank Light. The steamer D (390 feet by 17½ feet to 23 feet draught, 12 to 12½ knots) overtook and partly passed the seagoing tug L (150 feet by 15 feet draught) ("almost as fast"). The L was following a slightly converging course on the D's port hand, about 150 feet distant. When the stem of the L was abreast, or slightly forward, of the port side of the D's bridge, the L, which was bound up Raritan Bay, to D's starboard, slowed her engines "to let the D get well ahead, and was instantly caught in the suction of that vessel and drawn against her side," contact occurring "with the bow of the L against the D's port quarter, some 40 feet from the stern, with the tug at right angles with the steamship." Court held

Fig. 14. LAKE ST CLAIR

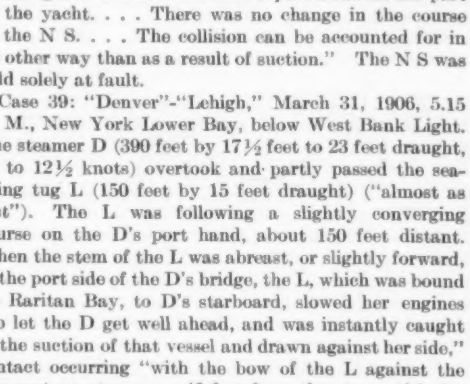
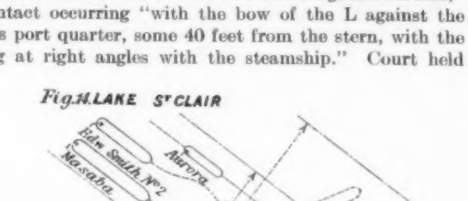


Fig. 15. Horseshoe Shoal



DELAWARE RIVER

DELAWARE RIVER
Scale 1" = 10,500 ft.
Fig. 16.

the L at fault for slowing, whereby "she surrendered a certain amount of power" and "became less manageable." Damages were divided. The water was 26 feet to 31 feet deep, with no marked lumps in the bottom.

Case 41: "Saratoga"-"Taunton," June 17, 1907, Delaware River, Horseshoe Bend (Fig. 15). This is an interesting case of bank-sheer. The S (430 feet by 50 feet by 18 feet draught), coming down the river at 8 knots with a helping tide of 2 to 2½ knots, struck and slipped off the "seventeen-foot lump" at buoy C 37, sheered suddenly about 4 points across the channel and collided with the T.

Case 43: "Parima"- "Prinzessin Irene," April 4, 1908, New York Lower Bay, 700 feet to 1,000 feet north of the buoy on point of the shoal between Main Ship and Swash Channels, and 1,700 feet to 1,800 feet west of the red bell-buoy. No court decision was ever rendered on the facts of this case, the following outline being the result of the author's attendance at the trial. The P (335 feet by 42 feet by 21.3 feet to 23 feet draught) was going down Main Ship Channel at 10½ knots, when she was overtaken on her starboard hand by the P I (524 feet by 60 feet by 22.6 feet to 24.8 feet draught) at an estimated speed of 13.8 knots. The ebb tide increased these speeds about one knot, and altered their apparent course 4 degrees or 5 degrees eastward. When the bow of the P I was abreast of the P's mid-length, and from 150 feet to 250 feet distant, the P sheered to port, ran over the perch-and-square buoy, and ran aground. The P libeled the P I as being the overtaking vessel and the cause of her going aground.

The case is, in the writer's belief, a plain case of repulsion of the leading ship during the first phase of passing. The water, which shows a general depth of 31 feet to 32 feet (plus 2 feet of tide), is amply restricted to account for the sheer, which took place against a hard-a-port helm. In addition, the 1:40,000 chart of New York Harbor shows a single sounding of 22 feet at or just north of the place of sheer; but a chart of 1:5000 which appeared in court did not fully corroborate this lump. But even without it, a sheer on the part of the smaller ship, passed at such speed and propinquity by a vessel of over three times her tonnage, drawing most of the water in the channel, would be only natural. This case is of further interest in that the officers of the P I were not aware, until they reached Germany, that their ship had been regarded as connected with the accident in any way.

Case 44: "Monterey"-"United States," April 16, 1908, 1.30 P. M., New York Lower Bay, Main Ship Channel, just above the entrance to Swash Channel, in almost the identical spot of Case 43, except further toward the westward side of the channel. Weather clear, wind light, tide last of ebb, netting 0.8 feet below the mean low water of the chart soundings. The twin-screw steamship M (341 feet by 47½ feet by 20 feet draught, 12 knots) was overtaken, "about abreast of the bell-buoy and well over to the westerly edge of the channel," by the U S (501 feet by 58 feet by 27½ feet draught, 15 knots), which was converging on the M's course by a half point. The clearance was stated as anything from 75 feet to 800 feet (the entire width of the channel being 1,100 feet), the court favoring 100 feet. "As the U S drew up abreast, the helm of the M was kept 'steady a-port,' a caution to the wheelsman to keep her perfectly straight and counteract any tendency of the vessels to veer together. When the U S was from one-third to one-half past and the bow of the M was opposite a point about two points abaft the beam of the U S, the M turned in the direction of the U S, notwithstanding a hard a-port helm and the starboard-engine being put full-steam astern, and the port-engine being kept going ahead to assist the port-helm. Upon its being found that these precautions did not have the desired effect, both engines were reversed at full-speed, but the collision occurred, the bow of the M striking the starboard side of the U S at an angle of about two points. There were two blows, one succeeding the other almost immediately." The U S was damaged to such an extent that it was necessary to beach her. The M was also seriously damaged, but she remained afloat.

The lump in the bottom of this channel, mentioned in connection with Case 43, apparently extends entirely across the channel. The depth at the black spar-buoy opposite the red bell buoy was 26.2 feet that day. Considering that the M, which must have been close to this buoy, was drawing 20 feet, while the U S drew over 27 feet, the slightest lump in the bottom would suffice, in addition to the half point of convergence, to develop a suction sheer. The lateral proximity of the bank on the M's starboard hand would also contribute a strong tendency to sheer to port, towards the U S.

It is also to be noted that, whereas in many cases of suction the sheer occurs in spite of hard-over helm, in this case it defied the controlling power of twin-screws as well. In the "Chicago"-"Owego" case (not reported here) the latter vessel, when she sheered, dragged one tug sideways through the water broadside and overcame the direct engine power of another, working in conjunction with partial power from her own engines. Such facts as these show how uncontrollable is the force of suction when once initiated.

Case 45: "Murcia"-"Sif," November 26, 1908, 2 P. M., Delaware River, Cherry Island "cut," opposite Wilmington, Del. (Fig. 16), weather clear and calm; flood tide. In the "cut," which is about 750 feet wide by 33 feet deep by chart, or 29 feet by testimony, the M (303 feet by 41.5 feet by 21 feet draught) was overtaken on her port side by the S (325 feet by 47 feet by 21 feet draught). Speeds are not stated; clearance stated contradictorily, but, according to the S, 300 feet to 400 feet. According to testimony on behalf of the initial clearance, when they began to overlap, was 100 feet to 150 feet, but that "as the S gradually drew ahead of the M the former converged slightly upon the course of the M, so that when the S was about half-way by the M the distance between them had been reduced to from 50 feet to 100 feet, when the engines were slowed, then stopped, and finally put full speed astern, and the helm a-port. . . . Notwithstanding this maneuver, the M continued to approach the S more rapidly, and then gave a sudden 'dive' in the direction of the latter, the bluff of the M's port bow striking the S on the starboard side at a point about 100 feet forward of the latter's stern. . . . Both vessels were injured."

The court quoted the opinion of Judge Gray in Case 25. In this present case, however, in contrast with Case 39, the pilot of the overtaken vessel was commended for slowing his engines. In this case, too, as in several others, the court leant toward the smaller of the variously stated clearances, on the ground that the time available would not permit the sheering vessel to cross a wider intervening space. But as nearly all these decisions have been rendered without any more accurate idea of suction than as a bodily attraction between the

two hulls, the rapidity with which a ship in motion can cross lateral space by being rotated rapidly while she moves ahead—which is what suction does, as well as accelerate the forward motion at the same time—has not been appreciated by the court. This line of reasoning annuls the court's conclusions as to the probable actual clearance, and makes it probable that many of these suction sheers occurred under initial clearances much greater than those stated in the court decisions.

Case 47: "Kennebec" - "Strathnairn," January 26, 1910, 8 A. M., Patapsco River, Baltimore Harbor, weather clear; wind light; tide, early ebb. The S (380 feet by 52 feet by 24 feet draught, 2,811 tons, 5 or 6 knots) came down the Sparrows Point Channel (100 feet wide by 25 feet deep) and made the almost square turn of 70 degrees into the Brewerton Channel (600 feet wide by 30 feet deep). There she met on her starboard hand the K (250 feet long, 1,930 tons, 7 to 9 knots), also going down Brewerton Channel When the ships met, their courses were parallel or slightly converging, the S being from 250 feet to 300 feet ahead, so that the K overlapped by 75 feet to 100 feet; lateral distance not stated. The vessels came together in the usual suction manner, but without room for as much angular rotation as usual; nor were the speeds high. Consequently the K struck the S with the side of her bow, and while each vessel was damaged, neither was disabled.

NEW BOOKS, ETC.

BRIEFER PHYSIOLOGY AND HYGIENE. With Practical Exercises. By Buel P. Colton, A.M., and Louis Murbach, Ph.D. New York: D. C. Heath & Co., 1914. 12mo.; 388 pp.; illustrated.

In this revision of a well-known text Prof. Murbach seeks to retain all the pedagogical values while embodying such newer views and data as are required in the first two years of a high school course. Correlated subjects have been unified and the text so arranged that it may be used for one-third year, one-half year, or a whole year's work. There are many new illustrations, and questions replace the old summaries.

HOW TO MAKE A LOW PRESSURE TRANSFORMER. By Prof. F. E. Austin, Head of the Department of Electrical Engineering at Norwich University, New Hampshire. 14 pp. Price, 25 cents.

This little manual gives plain directions for making a transformer which will change 110 volts to 8 volts as a minimum. It can also furnish a variety of pressures from 8 to 110 volts. It is rated as a 100-watt transformer. The directions are simple and plain, so that any one having a knowledge of electricity sufficient to operate the instrument should find no difficulty in following them in its construction. The transformer will light small tungsten lamps, run motors for fans or toy railways, ring bells, operate sparking devices for gasoline engines, and serve for many experiments.

LE HASARD. By Emile Borel. Paris: Librairie Félix Alcan. Price, 3 francs 50 centimes.

A thorough discussion of chance is possible only in a work of a mathematical character so profound that it would be hopelessly beyond the ordinary reader. But it is possible to give some idea of the methods which are employed by the mathematician in determining the probability of a certain thing's happening or not, and also to show how important it is to apply the doctrine of chances to science and to human affairs. Prof. Borel has performed this task extremely well. His book is divided primarily into three parts. The first is an exposition, without superfluous formulæ, of the principles of the doctrine of chance, such cases as fall within the theory of limited and unlimited alternatives and of inverse probability being taken up. The second part is devoted to the applications of the laws of chance to various sciences, such as sociology, physics, astronomy, biology and chemistry. The third part is of a philosophical character and gives the reader an idea of the manner in which chance plays its part in human affairs.

HISTORIC HOMES OF NEW ENGLAND. By Mary H. Northend, Author of "Colonial Homes and Their Furnishings." With numerous illustrations. Boston: Little, Brown & Co., 1914.

For many years Miss Northend's name has been familiar to the readers of monthly magazines, devoted to the home, as a writer on New England life. A resident of Salem and a member of a family well known in New England, she has brought to her work the sympathetic understanding which is to be expected of one whose character has been molded by the traditions of New England. In her present work she takes us by the hand as it were into the old mansions which have made New England architecturally famous—the House of the Seven Gables, the Pickering house, the Rogers house, the Adams house, the Governor Dummer mansion and others. Her descriptions of these wonderful old dwellings and her beautiful photographs of their exteriors and interiors should prove inspiring to our architects and to those who have a love for the best in our colonial architecture.

DYNAMIC EVOLUTION. A Study of the Causes of Evolution and Degeneracy. By Casper L. Redfield. New York: G. P. Putnam's Sons, 1914. 12mo.; 210 pp. Price, $1.50 net.

"Dynamic Evolution" puts forward a theory of animal energy, and postulates rules governing its transmission in increased or diminished quantity. A close examination of pedigree in stock is used as the foundation of the argument, which proceeds logically toward its application to man and mentality. The conclusion drawn is that transmitted energy, whether physical or mental, increases up to an advanced point with the age of the father. In support of this theory the author advances the fact that in the case of ten of the world's greatest men the average age of the fathers at the time of the sons' births is found to be no less than 55 years. The ten notables are Aristotle, Augustus, Bacon, Buddha, Confucius, Cuvier, Franklin, Humboldt, Ptolemy II, and Solomon. Sons of young fathers are declared to be inclined toward militarism and aggressiveness, sons of more mature sires to the fine arts and statesmanship, while the old fathers convey moral and philosophical bias.

ELECTRIC COOKING, HEATING AND CLEANING. A Manual of Electricity in the Service of the Home. By Maud Lancaster. Edited by E. W. Lancaster, A.M. Inst. C.E. American Edition revised by Stephen L. Coles, formerly Managing Editor *Electrical Review*. New York: D. VanNostrand Company, 1914. 8vo.; 329 pp.; 305 illustrations. Price, $1.50 net.

In England there are a score of districts where electricity for household purposes is obtainable at a cost of one cent per unit. As the American charges vary from 3 to 20 cents per unit, the advantage our English cousins possess—an advantage of which they have largely availed themselves—may be readily appreciated. Even under the handicap of high cost, however, the essential cleanliness and convenience of this service is daily widening its appeal. The attractive volume in hand, written by a woman especially for women, shows all the modern devices for cooking, heating and cleaning electrically, and describes their practical operation. The enthusiasm of the author is contagious, her points well made, and not to be overlooked is her strict attention to economy. The work is carefully adapted to the requirements of the American reader, and no small proportion of the apparatus it illustrates is of our own manufacture.

THE GAS TURBINE. By Norman Davey. New York: D. VanNostrand Company, 1914. 8vo.; 248 pp.; illustrated. Price, $4.

Of the two existing works in English on the gas turbine, the early monograph by Suplee is now inadequate, says Norman Davey, because it has nothing to say about the Holzwarth turbine, while Herr Holzwarth's book is inadequate because it has nothing to say of anything else. Mr. Davey gives us a comprehensive view both of theory and practice, and his contribution is opportune and welcome. Of the three types of gas turbine, the constant-pressure, mixed-fluid has been hitherto slighted. Considerable attention is here given to that type. A study of the variation in thermodynamic constants and its effect upon efficiency concludes the theoretical division of the volume. The discussion of practice includes the accessory machinery and practical limitations, summarizes efficiencies and compares types, and regards the gas turbine in the light of history, of experimental progress, and of future possibilities. A list of turbine patents from 1856 to 1913 is appended.

THE MISSISSIPPIAN BRACHIOPODA OF THE MISSISSIPPI VALLEY BASIN. By Stuart Weller. Illinois State Geological Survey, University of Illinois, Urbana, 1914. 4to.; text, 508 pp.; 83 plates separately bound.

The fossil yield of the Mississippian formations is exceedingly rich, and the present monograph is only a beginning toward a compact and accessible literature of their forms. All the known brachiopods of the region are described in this report, known as Monograph I. It discusses each species, and records the geological formation of which the species is a member. The volume of plates invariably mentions the exact locality of the specimen illustrated.

STEEL CONSTRUCTION. A Text and Reference Book Covering the Design of Steel Framework for Buildings. By Henry Jackson Burt, C.E. Chicago: American Technical Society, 1914. 12mo.; 381 pp.; illustrated.

In a handy, attractively bound little volume, a well-known and thoroughly competent structural engineer sets forth facts and formulas governing the erection of steel framework for buildings. Basic principles are lucidly explained. The practical illustrations accompanying the formulas conduce to independent thought on the part of the student, and at the same time demonstrate current practice. A sixteen-story fireproof hotel is presented in a complete set of drawings with all necessary explanations and details.

CARD READING. By Minetta. With Introduction by "Sepharial." Philadelphia: David McKay. 12mo.; 104 pp.; illustrated. Price, 50 cents.

The more impressionable sex may derive a dubious sort of pleasure from the dictum of the cards upon such vital questions as "Who is near to me?" "Who is dear to me?"—though one would think the answers to these scarcely required a resort to occult aid. The introduction seeks to place cartomancy upon a scientific basis. The result can by no stretch of courtesy be called convincing to the average intelligence.

ALCHEMY: ANCIENT AND MODERN. By H. Stanley Redgrove, B.Sc. (Lond.), F.C.S. Philadelphia: David McKay. 8vo.; 141 pp.; 16 full-page illustrations. Price, $1.50 net.

The old alchemy, whether regarded as a philosophy or a chemistry, is not devoid of interest. In its better-known, chemical aspect it inspired research, formulated laws, and evolved into practical pursuits. Admitting this, "Alchemy: Ancient and Modern," by devoting nearly a hundred of its one hundred and forty-one pages to the charlatans and charlatanry of a dead day, must be regarded rather as an historical study of curious human traits than a monograph on radio-activity, which is lightly disposed of in one short chapter. For this reason the work will commend itself to him who dreams in the past rather than to him who lives in the present.

PSYCHO-THERAPY. Its Doctrine and Practice. By Elizabeth Severn, Ph.D. Philadelphia: David McKay. 8vo.; 211 pp. Price, $1.25 net.

It is seldom that we have a book of this nature from a pen of such broad culture and practical philosophy. If the author claims too much for her method, toward her personal attainments she exhibits an admirable modesty and restraint. Her knowledge of human nature is so true that involuntary chuckles escape the reader from time to time. She represents the best side of mental treatment, shorn of all the isms that so frequently turn it to disaster. She does not seek to establish psycho-therapy upon a religious basis. Several chapters of the work may be read solely for the instructive glimpses they afford us of our frailties and the inner strength that may be summoned to overcome them. A novelist would find these a mine of character in which the author's own character is the richest nugget. Withal, her arguments are so circumstantially marshaled that we occasionally find ourselves convinced against our will.

AIR, WATER AND FOOD. From a Sanitary Standpoint. By Alpheus G. Woodman and John F. Norton, of the Massachusetts Institute of Technology. New York: John Wiley & Sons, Inc., 1914. 8vo.; 248 pp.; illustrated. Price, $2 net.

The three previous editions of this textbook have been favorably received, and as the present edition embodies the various advances that have been made in analytical methods it should meet with a like kindly reception. Originally written from the "missionary" standpoint, it has come into somewhat wide use as a text for colleges and technical schools. In it the three great essentials of our human existence are discussed in their relationship to health. Known facts are interpreted in an unprejudiced manner, and analytical methods take up much of the allotted space. Upon all the subjects dealt with, a wider and surer knowledge is a crying necessity, and the work is deserving of a growing circle of readers that shall pass on its teachings to the lasting benefit of their communities.

BILL'S SCHOOL AND MINE. A Collection of Essays on Education. By William Suddards Franklin. South Bethlehem, Pennsylvania: Franklin, MacNutt & Charles, 1913. 12mo.; 98 pp. Price, 50 cents.

"Bill's School and Mine" is in the large a contrasts between the free boy-life of the open country and the restricted environment of encroaching civilization. Other papers follow, on "The Study of Science" and "Part of an Education," all exhibiting a breadth of culture and a keen outlook on the part of the writer that is as rare as it is energizing. He not only has a distinctive way of saying things, but he has distinctive things to say. His remarks on the study of physical science are so embracing as to the various phases and difficulties of the question that we can but wish all parents, teachers and students might read and profit by them.

THE ART COMMISSION OF THE CITY OF NEW YORK. Report for the year 1913. 8vo.; 32 pp.; illustrated.

Aside from a list of the members and of committee appointments, this Report mainly concerns itself with the various public structures and works of art passed upon by the Committee during the year. It is enlivened by both approved and disapproved designs, as in the cases of the Swanstrom and Bowne memorials and the fire house plans. There are plates of old New York buildings of historic and architectural interest. A general sketch of the year's activities forms the subject-matter of the main section. The scope of the Commission is detailed, and there are illuminating paragraphs upon what constitutes true art in certain special environs and relationships. The Report should be welcomed by all who have the embellishment of the city at heart.

THE SPECTROSCOPY OF THE EXTREME ULTRA-VIOLET. By Theodore Lyman, Ph.D. New York: Longmans, Green & Co., 1914. 8vo.; 135 pp.; with diagrams. Price, $1.50 net.

Since the absorption of air is slightly apparent in the ordinary ultra-violet, the anterior portion of this monograph deals with that region of the spectrum which lies between wave-lengths 4,000 and 2,000. This is introductory to the real discussion, which is a study of the Schumann or extreme ultra-violet region. In this investigation Prof. Lyman deals with apparati and methods, with the absorption of solids and gases and their emission spectra, and with photo-electric and photo-abiotic phenomena. The author need not have apologized for the restricted field of his monograph. The careful research here detailed opens up a wide horizon, and physicists will welcome a handbook dealing exclusively with so interesting a subject

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